

A Prospective, Multicenter Study to Validate Use of the Pressure Ulcer Scale for Healing (PUSH[®]) in Patients with Diabetic, Venous, and Pressure Ulcers

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Abstract

Monitoring wound progress is essential for evaluating and documenting treatment outcomes. The Pressure Ulcer Scale for Healing (PUSH) was developed to track pressure ulcer (PU) progress but information about its utility for other types of chronic wounds is limited. A 10-month, descriptive, multicenter study was conducted to examine the responsiveness and concurrent validity of the PUSH when used to monitor wound changes in diabetic foot (DFU), venous leg (VLU), and PU. Using a convenience sample of participants ($n = 98$, mean age 60 [range 20 to 89] years, the majority [85%] male), PUSH score and acetate wound surface area tracings were obtained at baseline and approximately 4 weeks later from 47 Stage II to Stage IV PU, 23 VLU, and 28 patients with a DFU. After an average of 32 days, wound surface area, total PUSH scores, and individual PUSH component scores decreased significantly between baseline and follow-up ($P = 0.000$). The mean PUSH score change was significantly different between healing and nonhealing wounds ($P = 0.000$). A strong relationship ($r = .66$) was found between total PUSH score and surface area. Results suggest the PUSH tool is a valid, responsive, evaluative tool to monitor and document wound progress of PU, VLU, and DFU. Additional studies to assess use of this tool for DFU and to ascertain the predictive validity of the PUSH tool are warranted.

Key Words: clinical study, pressure ulcers, venous ulcers, diabetic foot ulcers, wound assessment

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Potential Conflicts of Interest: none disclosed

Measuring progress toward wound healing is an important component of chronic ulcer treatment programs — it ensures the wound care clinician that appropriate wound management is in place and allows the interdisciplinary team

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to reassess the treatment plan. The Pressure Ulcer Scale for Healing (PUSH®, National Pressure Ulcer Advisory Panel, NPUAP¹) was developed as a generic tool to provide a consistent, evidence-based tracking system for reporting wound healing progression or regression. Originally developed to prevent backstaging of PU, the tool consists of three parameters: wound surface area, exudate amount, and tissue type.¹

Literature Review

Thomas et al² completed a retrospective study of 37 patients with PU using a research database that included numerous variables associated with wound healing to test hypothetical models of healing. One ulcer was selected per participant; most were Stage III (46%) or Stage IV (35%). PU were assessed every 2 weeks for 8 weeks. Content validity was established by review of the literature and expert opinion. As a result, ulcer surface area, exudate characteristics, and surface appearance were used as key elements to measure wound healing. Principal component analysis using retrospective chart data indicated these parameters defined the best model of healing ($P < 0.01$).³ The authors concluded that the PUSH tool had content validity, correlation validity, prospective validity, and was sensitive to change.

Stotts et al's⁴ two retrospective chart review studies further validated the PUSH tool to track healing of Stage II through Stage IV PU. The first study included 103 adults with a Stage II (34.9%), Stage III (47.4%), or Stage IV (11.0%) PU from 10 different sites assessed weekly over 10 weeks. Principal component analysis confirmed the PUSH variables of surface area, exudate amount, and surface appearance provided the best model of healing and accounted for 58% to 74% of the variation across the 10 weeks. After the validation in Stotts' first study, the PUSH tool was pilot-tested in a long-term care facility. The findings led the authors to modify the original PUSH tool by refining size and predominant tissue type, expanding the length-times-width (l x w) category, and simplifying the scoring. The revised tool then was validated in a second retrospective study that involved 269 patients residing in long-term care who were assessed weekly for 12 weeks. Using the revised tool, principal components analysis showed the PUSH variables of surface area, exudate amount, and tissue type accounted for 39% to 57% of the variation over time for the group. The findings also suggested that for smaller ulcers or those in the final stages of healing the PUSH score velocity is not as sensitive to change as it is in larger ulcers. This loss of sensitivity was attributed to the difficulty of distinguishing small changes with integer numbers.⁴

In a prospective cohort study conducted by wound teams in two long-term, acute care hospitals for 1 year, Pompeo et al⁵ assessed an amended tool developed for use with the PUSH tool to enhance its use in clinical practice. PUSH tool scores were recorded for 374 patients with 989 wounds on admission and on discharge to quantify patient healing over an extended period of time for the purpose of monitoring overall healing

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Key Points

- Several tools exist to help monitor and document ulcer progress, as well as to obtain wound measurements.
- To date, most studies of the PUSH tool to track wound progress were conducted with pressure ulcer patients.
- The results of this study suggest that the tool may be valid and responsive to change when used for pressure, venous, and diabetic foot ulcers.
- Studies to assess its predictive validity for assessing chronic wounds are warranted.

outcomes of their wound program. The PUSH data were used as a point of reference to compare healing outcomes in different facilities; thereby, measuring the effectiveness of wound care treatment programs. The authors found the PUSH tool useful to collect data on all wounds found on the patient (wound type was not described).

Gardner et al⁶ researched the validity and reliability of the PUSH tool 3.0 in a prospective study of PU patients. Nursing home residents at three different sites were assessed weekly using the PUSH and the Pressure Sore Status Tool (PSST) as well as acetate tracings of the wound. Assessments continued until the ulcers healed or the resident died, was transferred from the facility, or completed 6 months of follow-up. If residents had more than one ulcer, all were assessed and included in the study. Of the 23 participants' wounds, 69% were Stage II, 19% were Stage III, 6% were Stage IV, and 6% were unstageable; the majority of wounds (55%) were present for 2 weeks or less. The authors found that total PUSH score at baseline was significantly lower ($P = 0.10$) among the patient's whose ulcers closed (healed ulcer group) versus those who did not close (unhealed ulcer group) during the study. PUSH items analysis revealed the healed ulcer group had significantly lower l x w scores at baseline compared with the unhealed group. No significant difference was found in the item scores for tissue type or exudate amount. They also found that total PUSH scores decreased significantly ($P = 0.00$) from weeks 1 through 5 in the healed but not in the unhealed ulcer group. Reviewing the individual PUSH tool items for the healed ulcer group, l x w decreased significantly ($P = 0.00$) from weeks 1 through 5 but tissue type and exudate amount did not. Total PUSH scores were also highly correlated with both the PSST and surface area measurements. This correlation increased over time as the wounds progressed toward closure. The authors concluded the PUSH tool provides a valid measure of PU healing over time and accurately differentiates a healing from a nonhealing PU.

Given that the parameters of the PUSH tool are not specific to wounds of one etiology, Ratliff et al⁷ assessed the respon-

Table 1: Inclusion and exclusion criteria**Inclusion Criteria**

Over 18 years of age

Able to provide consent and understand the purpose of the study

Has a wound with the potential to heal as assessed by student researcher

Potential to heal in this study is defined as:

- *underlying cause can be corrected or treated*
- *patient-centered concerns have been addressed*
- *wound dressings have been selected to promote moist interactive wound healing*

Stage II, Stage III, Stage IV pressure ulcer (NPUAP 2007)³⁰

Venous leg ulcers or

Diabetic foot Grade 1A and 2A

(University of Texas Classification of Diabetic Foot Wounds)³¹

Exclusion Criteria

Wound without visible base (eg, Stage I and unstageable wound)

Wound contains advancing active infection

Arterial wound

Wound resulting from a malignancy

Wound of unknown etiology

Participant is unable to commit to follow-up (reassessment post 4 weeks)

Participant's geographic area is beyond student researcher ability to follow-up

Multiple wounds deleted – not an exclusion

siveness of the PUSH tool for use in venous leg ulcers (VLU). The tool was used to assess 27 VLU patients over 2 months at initial and subsequent visits. If the patient had more than one ulcer, only the largest ulcer was included in the study. The mean PUSH score decreased in 23 and increased in four patients with average scores changing from 12 on the first visit to 9 and 8 on the second and third visits, respectively. It was concluded that the PUSH tool was a reliable and practical tool for monitoring the process of VLU healing.

The PUSH tool is a quick and easy approach to wound assessment that could easily be added to clinical practice. Other wound assessment tools — eg, PSST and the Leg Measurement Tool (LUMT®) — involve a greater number of evaluated domains (items), take more time to complete, and require prior training to execute.^{8,9} In a survey of PUSH tool users by Berlowitz et al,¹⁰ 79 out of 103 respondents reported the PUSH tool was easy to use and time-efficient. Although most users were utilizing the PUSH tool to monitor PU healing, 27% of the respondents were using the tool to monitor wounds of different etiologies. It was concluded that clinicians with varied professional training were using the PUSH tool for different purposes and across healthcare settings.¹⁰ This has been reinforced in the literature, given that the PUSH tool has been used as a measure of healing for different patient populations in a variety of healthcare environments¹⁰⁻¹⁵ and has been adapted for use in different languages.¹⁶

However, the PUSH tool continues to be under-utilized in the wound care community, which may be related to the fact that it assesses only three parameters of wound healing even though statistical analysis has not demonstrated that other parameters for healing (eg, depth) contribute to the tool's validity in measuring PU healing.¹⁷ As defined by the Centers for Medicare and Medicaid Services (CMS), for a wound to be “measurable it must show a decrease in area or volume, a decrease in exudate amount, or a decrease in necrotic tissue.”¹⁷ These parameters are not etiology-specific — ie, all wound types are included in this description. Other outcome measures in wound healing, such as those developed to measure diabetic foot and leg ulcers, also include wound size, base, and exudate as parameters in more comprehensive assessment tools for predicting wound closure.^{9,18}

The PUSH tool is not designed to be an indepth assessment instrument to guide treatment decisions, but rather an efficient bedside tool to measure wound progress. Thus, increasing the number of wound healing parameters in the PUSH tool would compromise the original purpose for which it was developed and the need for a tool that

is time-efficient, clinically practical, and can be used at the bedside by a variety of clinicians in a wide range of settings. This is especially important in the diabetic foot ulcer (DFU) population where a tool for monitoring wound progress is lacking.

Study Purpose

The purpose of this prospective multicenter study was to validate and evaluate the responsiveness of the PUSH tool version 3.0 in patients with chronic wounds of all etiologies by addressing the following research questions: 1) What is the concurrent validity of the total score and the individual domains of the PUSH tool compared to acetate tracing? 2) Is there a difference between total PUSH scores in healing versus nonhealing ulcers? 3) Can the PUSH tool be used to detect change in wound status over time? 4) Can the PUSH tool be used to detect change in diabetic foot, venous, and pressure ulcers?

Methods

Population. A prospective, descriptive multicenter study was conducted over 10 months (from October 2007 to July 2008) by various healthcare professionals (nursing, chiropody, occupational therapy, and physiotherapy) across diverse clinical settings including acute care inpatient setting, outpatient wound clinic, and the community, involving patients with

DFU, VLU, and PU. A sample size calculation indicated that with 50 participants in each wound category, a statistical power of 80% would detect a correlation as low as 0.40 with two-tailed alpha of 0.05. This means that if the correlation is higher, statistical power can detect it. It also means that if the wound categories are combined to include 150 participants, 80% statistical power would detect a correlation <0.30 with two-tailed alpha of 0.05.¹⁹ In order to analyze responsiveness of the PUSH tool, a sample size of 16 participants is required to achieve a responsiveness (change/SD change) of 0.8, assuming alpha of 0.05.²⁰

Procedure. Once ethical review board approval was obtained from the individual institutions, a convenience sample of 105 adult participants who met the study inclusion and exclusion criteria (see Table 1) was recruited. Written informed consent was obtained from each participant and a number was assigned to protect study participant identity and privacy. Total PUSH score and acetate surface area tracings were obtained twice by the same investigator, once at baseline and once approximately 4 weeks later or at the patient's next appointment, whichever came first. Investigators were from different healthcare professions (a nurse, an occupational

therapist, a chiropractor, and two physical therapists) and had a combined clinical experience of 69 years. Before the study, investigators were trained on PUSH tool use and consensus was established among the assessors for the criteria of the PUSH tool components, including l x w measurement, exudate amount, and tissue type assessment. If the participant had more than one wound, an index wound (largest wound) was selected by the investigator to be followed in this study.

On initial assessment, the following information was collected in addition to the PUSH tool items; gender, age, and type and location of wound. At the first and second wound assessment, the participant's dressing was removed and the investigator estimated the amount of exudate before cleansing. All wounds were irrigated and debrided if required and length and width were measured using a disposable ruler and the clock system where length was always measured in line with the patient's head and feet. The type of tissue present in the wound base also was documented. Total PUSH score was calculated by adding the subscores according to the tool's instructions; total score ranges from 0 (healed) to 17 (most severe wound).¹ Immediately following the PUSH tool assessment, an acetate tracing was obtained. The two-layer ac-

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Table 2. Change in wound size^a between baseline and follow-up assessments

	Total Group	Pressure ulcer (All)	Pressure ulcer (Stage II)	Pressure ulcer (Stage III)	Pressure ulcer (Stage IV)	Venous leg ulcer	Diabetic foot ulcer	Healing ^b	Nonhealing ^b
Number of study participants	98	47	15	16	16	23	28	79	19
Mean (SD) wound size (cm ²) at baseline	7.1(10.1)	9.2(12.3)	5.6(4.9)	5.3(4.5)	16.6(18.2)	7.8(8.8)	2.9(4.2)	7.0(9.6)	7.5(12.1)
Mean (SD) wound size (cm ²) at follow-up	4.7(9.1)	6.2(10.8)	2.4(3.7)	3.6(3.8)	12.8(16.5)	4.8(9.3)	2.1(5.1)	3.5(7.2)	9.5(14.3)
Mean (SD) change in wound size (cm ²) between assessments	2.4 (4.1)	3.0 (4.8)	2.9 (3.6)	1.9 (2.9)	4.3 (6.9)	3.1 (3.9)	0.8 (2.1)	3.5 (3.7)	-2.1 (2.3)
P value	0.0001 ^c	0.0001 ^c	-	-	-	0.001 ^c	0.1	0.0001 ^c	0.0001 ^c
Mean time (SD) between assessments (days)	31.7(20.1)	25.4(5.6)	29.5(3.4)	22.4(3.4)	24.6(6.7)	25.5(4.8)	47.5(32.0)	29.1(14.7)	43.2(34.0)

a Wound size measured using acetate tracings.
 b Healing = decrease in wound surface area. Nonhealing = wound surface area increase or no change
 c Statistically significant difference (alpha=0.05) between baseline and follow-up (31.7 +/- 20.1 days later)

etate was held firmly against the wound and the wound outline traced with a thin-tip permanent felt pen. The acetate layer touching the wound was discarded and the tracing placed in the study participant’s chart. Wound surface area was determined automatically by outlining the wound tracing on the Visitrak® digitization tablet (Smith & Nephew, Quebec, Canada). After the assessment, a new dressing was applied per the prescribed dressing protocol.

Data and statistical analysis. Data were de-identified and compiled on a Microsoft Excel spreadsheet for Windows 2007 and SPSS version 14 (SPSS, Chicago, IL). Pearson’s product moment correlation coefficient was used to test the relationship between PUSH score and surface area tracing. The relationship between the change in PUSH score and change in surface area, as well as the relationship between baseline PUSH score and baseline surface area, was calculated for the total group, for each wound category, and for healing and nonhealing wounds (defined as reducing or increasing surface area). Spearman’s rank order correlation coefficient was used to test the relationship between the individual PUSH score domains and acetate tracing surface area. Cohen’s²¹ work was used as a basis for determining strength of the correlations; a strong or large correlation coefficient was defined as $r = 0.5-1.0$, a moderate or medium correlation coefficient was defined as $r = 0.3-0.5$, and weak or small was defined as $r = 0.1-0.3$. Differences in the PUSH score were compared between healing and nonhealing ulcers using a Student’s *t*-test. The ability of the PUSH tool to detect change over time was tested using the paired *t*-test. A *P* value <0.05 was considered statistically significant. Values for effect size (ES, mean /SD baseline) and standardized response mean (SRM, mean /SD) were calculated. These values were used to describe responsiveness of the total PUSH score, each of the three domains of the PUSH tool, and each type of wound (PU, DFU, and VLU). The determination of the magnitude of ES and SRM was based on Kazis et al’s²² work (large >0.8, moderate 0.50–0.79, small 0.20–0.49, and very small 0.00–0.19).

Results

Participant demographics and wound variables. Of the 105 patients enrolled, 98 completed the study and were included in the statistical analysis. One patient died, four were lost to follow-up, and two were excluded following initial enrollment (one surgical wound and one very large wound that was difficult to accurately trace with the acetate). Participants included men and women (85% and 15% of the sample, respectively), mean age 60 years (range of 20 to 89 years). Over the course of the study, 48.9% of the wounds were debrided. The sample comprised 47 PU (15 Stage II, 16 Stage III, and 16 Stage IV ulcers); 23 VLU, and 28 DFU. The majority of the wounds were located on the forefoot (25%), ischial tuberosity (16%), heel (15%), sacrum (12%), and medial malleolar region (10%). Mean baseline surface area, as measured using acetate tracings, was 7.1 cm² (range 0.1 cm² to 62.1 cm²) and mean follow-up surface area was 4.7 cm² (range 0.0 cm² to 56.7 cm²). Mean follow-up time was 32 days (range 14 to 133 days) and 80.6% of all ulcers were classified as healing (reduction in wound surface area) (see Table 2).

PUSH score outcomes. Mean baseline PUSH score was 11



Table 3. Change in PUSH score between baseline and follow-up assessment

	Total group	Pressure ulcer (all)	Pressure ulcer (Stage II)	Pressure ulcer (Stage III)	Pressure ulcer (Stage IV)	Venous leg ulcer	Diabetic foot ulcer	Healing ^a	Nonhealing ^b
Mean score at baseline ^b (SD)	11.0(3.1)	12.1(2.8)	10.6(2.7)	11.3(2.3)	14.2(2.1)	11.6(3.0)	8.9(2.8)	11.2(3.0)	10.6(3.7)
Mean score at follow-up (SD)	8.0(4.5)	9.4(4.2)	6.5(5.0)	9.4(2.5)	12.3(2.4)	6.8(4.9)	6.5(4.3)	7.2(4.4)	11.1(3.7)
Mean score change (SD)	3.0(3.7)	2.6(3.3)	3.7(4.9)	2.3(2.3)	1.8(2.1)	4.8(4.0)	2.3(3.6)	3.9(3.4) ^c	-0.6(2.3) ^c
P value	0.0001 ^d	0.0001 ^d	0.01 ^d	0.01 ^d	0.01 ^d	0.0001 ^d	0.02 ^d	0.0001 ^d	0.2
Effect size	.97	.93	1.4	1.0	.86	1.6	.82	1.3	-.16
Standardized response mean	.81	.79	.76	1.0	.86	1.2	.64	1.15	-.26

a Healing = decrease in wound surface area. Nonhealing = wound surface area increase or no change
 b PUSH score range 0 (healed wound) – 17
 c Difference between healing and nonhealing wounds $P = 0.000$
 d statistically significant difference ($\alpha = 0.05$) between baseline and follow-up assessments (31.7 ± 20.1 days later).

Table 4. Responsiveness of individual PUSH score components

	Score components (normal range)		
	Size (l x w) ^a (range 0–10)	Exudate amount (range 0–3)	Tissue type (range 0–4)
Mean (SD) baseline score	6.5(2.3)	2.0(0.7)	2.6(0.7)
Mean (SD) follow-up score	4.8(2.3)	1.5(0.9)	1.7(0.7)
Mean (SD) score change	1.7(2.4)	0.5(0.9)	0.9(0.9)
P value	0.0001 ^b	0.0001 ^b	0.0001 ^b
Effect size	.74	.71	1.29
Standardized response mean	.71	.56	1.00

a Obtained using disposable ruler
 b Statistically significant difference ($\alpha = 0.05$) between baseline and follow-up assessments (31.7 ± 20.1 days later)

tissue type also were found to be responsive to change in all ulcers, with tissue type having large, l x w moderate, and exudate small ES and SRM values, respectively (see Table 4).

Concurrent criterion validity.

The Pearson’s correlation coefficients for the relationship between baseline acetate surface area and baseline PUSH score were strong in all types of wounds and strongest for the DFU ($r = .71$), VLU ($r = .74$), Stage II ($r = .77$), and Stage III PU ($r = .88$) (see Table 5). Using Spearman’s correlation, l x w surface area and exudate amount domains of the PUSH score

(range 4 to 17) and mean follow-up score was 8 (range 0 to 16). Total PUSH score at baseline was similar for healing (11.2) and nonhealing (10.6) wounds, respectively. At the follow-up assessment, the PUSH score decreased to 7.2 in healing wounds, which was significantly ($P = .001$) less than PUSH scores in nonhealing wounds (11.1) (see Table 3). A significant difference also was noted between the change in PUSH score in the healing and nonhealing groups ($P = .000$) (see Table 3).

PUSH tool responsiveness. The PUSH tool was found to be responsive in the total group and for all pressure, venous leg, and diabetic foot ulcers (see Table 3). The largest ES and SRM were found in Stage II and Stage III PU and the VLU, although ES and SRM were large for all groups. Large ES and SRM also were calculated for ulcers that had a reduction in wound surface area over the evaluation period (healing group). These values were negative and very small for individuals with nonhealing ulcers (see Table 3). Each of the individual PUSH score domains of l x w, exudate amount, and

at baseline were found to correlate strongly with wound surface area and the tissue type domains correlated moderately with wound surface area. Change in all the three components of the PUSH scores correlated moderately with change in surface area measured using acetate tracings (see Table 6).

Discussion

Using a valid and responsive wound assessment tool is important when evaluating treatment progress. An assessment tool that is simple to use and applicable to different wound etiologies would be ideal for healthcare professionals working in varied clinical settings. The PUSH tool was originally developed as a simple tool to monitor PU progress. Assessment tools such as the Sessing,²³ Photographic Wound Assessment Tool (PWAT),²⁴ PSST,⁸ and Leg Ulcer Measurement Tool (LUMT®)⁹ have been shown previously to detect a change in wound status over time. The Sessing tool has only been used on PU and the LUMT was designed for leg ulcers; therefore,



Table 5. Baseline wound size and baseline total PUSH score correlation

	Total group	Pressure ulcer (all)	Venous leg ulcer	Diabetic foot ulcer
Pearson's r	.66	.63	.74	.71
P value	0.01	0.01	0.01	0.01

Table 6. Baseline wound size and individual PUSH Score components correlation

	Size (l x w) range 0-10	Exudate range 0-3	Tissue type range 0-4
Spearman's rho	.83	.54	.41
P value	0.01	0.01	0.01

neither of these wound assessment tools could be used universally on all types of wounds. The PWAT was not designed to capture other clinical attributes such as pain and odor; it assesses digital images only. Currently, no assessment tool is available that has been shown to detect changes in wound appearance of DFU.

This study is the first to demonstrate the PUSH tool is responsive to change in all three wound types. In addition, the change in mean PUSH tool score was significantly different ($P = 0.00$) between healing wounds and nonhealing wounds in this study sample. The authors found strong and significant correlations between baseline total PUSH score and wound area measurements determined by acetate tracing. These findings suggest the PUSH tool is a valid and responsive tool in evaluating healing DFU, VLU, and PU. Acetate tracing of surface area is different than length-times-width determination of wound size used in the PUSH tool although they both measure wound size. A strong correlation would be anticipated between acetate tracing and length-times-width determination; a strong correlation between acetate tracing and either exudate or tissue type would not be expected.

This study supports similar findings reported by Gardner et al,⁶ who assessed the PUSH tool for change over time in 32 PU samples using repeated measure analysis. The authors found the PUSH tool was sensitive to detect change in their healed participants and could accurately differentiate a healing from a nonhealing ulcer.

When analyzing responsiveness to change based on PUSH components, tissue type was found to be most responsive to change, followed by l x w and exudate amount. The relatively high ES for the domain that assessed tissue type may be explained by the use of sharp debridement performed in 48.9% of wounds included in this study. The lower ES and SRM of the exudate amount domain could be explained by a smaller range in scores for this component.

Exudate was assessed before wound cleansing so the amount of exudate between dressing changes could be evaluated. This is consistent with directions provided by the PUSH tool that indicate “the exudate is to be estimated after removal of the dressing and prior to applying any topical agents to the wound”.¹ Because some dressings interact with wound exudate (hydrocolloids), this could have yielded an inaccurate estimate of exudate. However, because this approach was applied consistently by a single rater on both occasions, the effect of the dressing on wound exudates would likely be minimal over time and have minimal effects on the ability of the PUSH tool to detect real changes in wound status over time.

This is the first study to validate the PUSH tool for use in a sample of 28 DFU. This study found a strong responsiveness to change in total PUSH score for these wounds. Change in wound surface area of DFU was more difficult to detect, confirming that detecting change in smaller wounds (<10 cm²) is difficult and subject to precision errors.^{4,25} The stronger responsiveness to change in total PUSH score maybe attributed to the influence of the other two domains in the PUSH tool (exudate and tissue type), which are more likely to change initially when these chronic wounds begin to heal. These preliminary data for DFU suggest the PUSH tool is valid and responsive to wound changes in this population. However, a larger sample size, using a criterion measure that accounts for both wound size and appearance, is warranted to confirm this finding.

For VLU, this study supported the preliminary findings reported by Ratliff and Rodeheaver⁷ that demonstrated a change in mean PUSH score over a 2-month period using a small population of people with VLU.

For PU, the correlation between change in wound surface area and PUSH score was highest in Stage III pressure ulcers. Overall, concurrent criterion validity has been established by the relationship between change in PUSH score and change in wound surface area tracings in PU of different stages in this study. The PUSH tool demonstrated a stronger responsiveness to change in Stage II PU (ES = 1.4) than in Stage III (ES = 1.0) and Stage IV PU (ES = 0.86). Overall, the strong ES indicates the PUSH tool is highly responsive to change in PU.

Limitations

This study lacks a gold standard criterion comparing all components of the PUSH tool. Wound measurement using acetate tracings was chosen because it commonly appears in the literature.^{6,18} Wound surface area measurement has been shown to be an extremely reliable way of monitoring wound healing between assessors and percent change in wound area is an established predictor of treatment outcome.²⁶⁻²⁹

Although PUSH scores were shown to be responsive to change, the calculated values for ES and SRM likely would have been improved if participants in this study had been followed for a longer period or to wound closure. The intention was to collect wound assessments at 0 and 4 weeks; however,



in reality wounds were assessed between 14 and 133 days. This was because study participants either were discharged early or were unable to return for follow-up appointments. This variable range between assessments is indicative of typical clinical practice. More frequent assessment conducted every 2 weeks would be ideal; however, it was not practical in a busy clinical setting. Having a tool that is responsive over 1 month when used on chronic wounds of several different etiologies is extremely useful in the clinical setting.

Although an inter-rater reliability assessment was not conducted in this study, the definitions developed for wound measurements and description in the PUSH tool have shown high inter-rater reproducibility in PU studies.¹² The investigators reached consensus on the method for wound measurement, defined wound appearance, and parameters. In addition, the same assessors completed the initial and follow-up assessments in order to ensure consistency.

Although data were collected by clinicians working in different healthcare settings, data were not analyzed by clinical setting (acute care inpatient, outpatient clinic and homecare). This would be of interest for future studies with greater sample numbers spread evenly across several different locations. This study had a relatively small, convenience-based, sample size. The external validity of this study would be strengthened by future work involving a greater number of study participants. The inter- or intra-rater reliability of the PUSH tool has not been reported previously and therefore should be assessed in future work. Also, while the results of this study suggest that PUSH tool score changes are sensitive to healing trends, research to determine whether initial changes in PUSH scores are better able to predict healing than changes in wound area alone are needed.

Conclusion

A prospective, descriptive multicenter study was designed to validate the PUSH tool in monitoring wound healing for use in pressure, venous leg, and diabetic foot ulcers, further defining the PUSH tool's clinical utility. This study was undertaken by various healthcare professionals across diverse clinical settings. The results indicate that the PUSH tool is valid and responsive for assessing healing PU, VLU, and DFU and concurrent validity between wound surface area tracing and total PUSH score was good. The PUSH tool can be used by different healthcare professionals to monitor wound healing progress across the continuum of clinical care.

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