

# DMIST Scale for Predicting Healing Time within 12 Weeks in Patients with Diabetic Ulcer

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**Abstract: Background:** *An assessment scale, namely, the DMIST (deep, moisture, infection/inflammation, size, tissue type of wound bed, type of wound edge and tunnelling/undermining), was designed to identify the healing time of chronic ulcers. An evaluation was then conducted to test the predictive validity of DMIST. This study aimed to evaluate whether the total scores from the DMIST scale could predict healing time of diabetic ulcer.*

**Method:** *A prospective study cohort was obtained from the Kitamura Wound Clinic in Pontianak, Indonesia. A total of 33 patients with diabetic ulcer were recruited to participate in the study. Collected data included DMIST score, demographic information, Wagner wound classification, neuropathic status, ankle brachial index, HbA1c level and wound images. Using the DMIST scale, trained data collectors scored patients every 7 days until ulcers were healed or patients were discharged.*

**Results:** *A cutoff score of 9 was valid as a predictor of non-healing after 12 weeks. The DMIST scale was found to have high sensitivity (90%) and specificity (96%). The area under the receiver operating characteristic curve was 0.98 (95% confidence interval, 0.856 to 1.000).*

**Conclusion:** *The DMIST scale was found to be a valid assessment scale to identify wound healing time in a period of 12 weeks in patients with diabetic ulcer.*

**Keywords:** *sensitivity, specificity, diabetic ulcer, wound healing*

## 1. INTRODUCTION

Healing of chronic wounds is extremely complex, and chronic wounds require extensive treatment, especially in patients with diabetes-related wounds. Various factors can cause impaired wound healing by affecting one or more phases of the process and are categorised into local and systemic factors. The study reported that, despite adequate conservative care, many diabetic ulcers fail to heal in a timely manner (Dinh, Elder and Veves, 2011). Literature reviews showed varying chronic wound healing times, ranging from 8 to 12

weeks or longer (Dinh, Elder and Veves, 2011; Zelen *et al.* 2015; Kimmel and Gittleman, 2017; Wang *et al.* 2019). One study reported that <31% of diabetic neuropathic foot ulcers healed after 20 weeks of good wound care and revealed a healing rate of 24% after 12 weeks of treatment (Margolis *et al.* 2002). Wound healing in patients with diabetic ulcers is extremely long, even up to 1 year and more (Margolis *et al.* 2002; Marston *et al.* 2020). Therefore, an assessment of wound healing is needed to identify progression and determine appropriate wound care management. A diabetic foot ulcer assessment scale was developed using seven domains: depth, maceration, inflammation/infection, size, tissue type of wound bed, type of wound edge and tunnelling/undermining (Oe *et al.* 2020). This scale is called DMIST, an abbreviation of the seven domains. The DMIST scale is a summated rating scale consisting of seven subscale scores from 0 to 9 (but only one reaches 9). The total scores ranged from 0 to 34, with higher scores indicating a worse prognosis of wound healing. The scale was designed with size and type of necrotic tissue selected as domains that might be easily evaluated by not only wound care specialists but also non-specialised healthcare providers (Oe *et al.* 2020). Moreover, a domain for tissue type of wound bed was established by adding the concept of granulation tissue to the domain of the type of necrotic tissue. The reliability and validity of this scale were evaluated. In the inter-rater reliability, the intraclass correlation coefficient for total DMIST score was 0.905 (Oe *et al.* 2020). Then, the validity study found that DMIST score of 9 showed the best balance of sensitivity (0.855) and specificity (0.786) for wound non-healing after 4 weeks. Studies have reported that diabetic ulcers mostly heal in 12 weeks (Dinh, Elder and Veves, 2011; Warriner, Snyder and Cardinal, 2011; Hart, Loewen-Rodriguez and Lessem, 2012; Bolton, 2016; Pourvaghar *et al.* 2016; Estelle and Mathioudakis, 2017; Zelen *et al.* 2017; Cho *et al.* 2020; Marston *et al.* 2020). The healing time of diabetic ulcers is generally 12 weeks, which need to be investigated using an assessment scale. This study aimed to evaluate the sensitivity and specificity of the DMIST scale in terms of predicting healing time of diabetic ulcers in 12 weeks.

## 2. MATERIALS AND METHODS

A prospective cohort design was used in this study, which was conducted at the Kitamura Wound Clinic in Pontianak, Indonesia. Sampling was conducted using a convenience sampling method. Outpatients with diabetic ulcer who met the exclusion criteria (age  $\geq$  18 years, any history of stroke affecting extremities, ischaemia ulcer, amputation, no initial treatment, peripheral oedema and severe cellulitis) were excluded in the study. Two registered nurses certified in diabetic wound care conducted wound and physical assessments, which include DMIST scale use, neuropathic status examination, ankle brachial index (ABI) measurement and Wagner classification. Two assistant nurses as assessors used their assigned DMIST scale to independently assess the ulcers weekly until healing at 12 weeks or patient discharge. Two nurses recorded various data, such as respondents' characteristics and wound images. Neuropathic status was examined using Semmes–Weinstein monofilament test with a reproducible buckling load of 10 g. The monofilament was placed on the portion of the patient's skin, which had no callus and pressed as far as the monofilament could be bent. Four sites (1st, 3rd and 5th metatarsal heads and plantar surface of distal hallux) were assessed on each foot.(Boulton *et al.* 2008). In each point, the assessment was repeated three times. If the patient answered incorrectly two or more times in that point, it was indicated as a

positive symptom of neuropathy (Boulton *et al.* 2008). The images were captured after the wound areas were cleaned, and a paper ruler was used to measure the widest and longest dimensions of the ulcer. The wound area was calculated in square centimetres by multiplying the greatest length by the greatest width perpendicular to the greatest length. ABI assessments were performed after a 10-min adaptation in supine position using a handheld Doppler device (Bidop ES-100V3, Hadeco-Kawasaki, Japan) on both dorsal and posterior tibialis of the foot by calculating the ratio of the systolic pressure at the arm level to the systolic pressure at the ankle level of both sides. To evaluate the accuracy of the DMIST scale, diagnostic probabilities (sensitivity and specificity) were calculated for the range of DMIST scores. The predictive validity of the DMIST scale was determined to predict healing and non-healing wounds in 12 weeks using the area under the receiver operating characteristic (ROC) curve. Descriptive analysis was used to calculate the characteristics of patients. Statistical analyses were performed using IBM SPSS Statistics version 20, and predictive validity was assessed using MedCalc<sup>®</sup> version 15.8. Institutional ethical clearance was obtained from The Muhammadiyah Institute of Nursing (board no. 77/II.IAU/Ket.ETIK/S-1/III/2019), and informed consent was obtained from the subjects.

### 3. RESULTS

This study was conducted from October 2019 to March 2020. Table 1 shows the breakdown of the sample, with 33 recruited patients with diabetic ulcer, in which 75.8% were female and 24.2% were male. The median age of the sample was 54 years, and other measures were as follows: positive for neuropathy, 30.3%; negative for neuropathy, 69.7%; the median ABI, 1.14 (0.70–1.40); the median HbA1c level, 9.50% (6–14); the mean systolic pressure,  $143.3 \pm 31.17$  mmHg; and the mean diastolic pressure,  $88.9 \pm 17$  mmHg. The dominant severity of the wounds in this study was grade 2 (80%) for healing time in 12 weeks (Table 2). The predictive validity test indicated that a cutoff DMIST score of 9 produced the best balance of sensitivity and specificity (90% and 96%, respectively). The DMIST sensitivity (Fig. 1) was plotted versus 1-specificity for each possible DMIST score to generate the ROC curve. The AUC (area under the curve) was 0.98 (95% confidence interval, 0.856–1.000).

### 4. DISCUSSION

This study found that the DMIST scale was a valid scale in assessing wound healing in patients with diabetic ulcer and could predict the healing time of ulcers in a period of 12 weeks. The AUC indicated that the DMIST scale has a high level of accuracy (Akobeng, 2007) . and could distinguish between patients with a healing time within and more than 12 weeks. This study confirmed the results of a previous study that a cutoff DMIST score of 9 was valid as a predictor of non-healing time after 4 weeks (Oe *et al.* 2020). A new finding in this study followed that of a previous study and consistency in using the same cutoff score, which demonstrated higher level of accuracy in terms of predicting healing time in 12 weeks. Moreover, this study supported previous findings on non-healing after 4 weeks (Oe *et al.* 2020) to predict complete healing time in 12 weeks.

The study was based on a review of the literature, which presents various findings in terms of healing time of diabetic ulcers. In the case of neuropathic, neuro-ischaemic and ischaemic

ulcers, the average healing times in 50% of patients were 70, 113 and 233 days, respectively (Yotsu *et al.* 2014). One study on patients with large diabetic ulcer on their legs (treated with honey dressing) reported healing times of <12 weeks (Astrada *et al.* 2019). Another study using the same treatment reported healing time of 120 days (Manalelsayedez *et al.* 2012). In addition, patients who had neuropathic and neuro-ischaemic ulcers healed after 70 days (longer for peripheral occlusive vascular wounds (Zimny, Schatz and Pfohl, 2002) . One meta-analysis of randomised clinical trials reported that healing time of diabetic ulcers was between 12 and 16 weeks (Huang W *et al.* 2020). Another study reported 90–100% diabetic wound healing rates with a wound closure range of 6 to 12 weeks (Zelen, 2013; Zelen *et al.* 2015, 2016, 2017; Tettelbach *et al.* 2019). With wounds rated as grade 2 according to the Wagner wound classification system, wound healing was achieved in a period of 12 weeks (Manalelsayedez *et al.* 2012; Kumar *et al.* 2016; Serena *et al.* 2020). Wagner grade 2 or 3 diabetic ulcer healed in 12 weeks, (Bolton, 2012), and Wagner 3–4 wounds in a period of 1 year (Kumar *et al.* 2016; Marston *et al.* 2020), Our study results indicated a distribution ranging from grades 1 to 4 for Wagner’s wound classification. Most patients had a grade 2 wound, indicating that it could be described as a diabetic ulcer, which would generally be expected to heal within 12 weeks (You, Han and Rhie, 2014; Bolton, 2016) . However, this study also confirmed the result of a meta-analysis and randomised control trial that most diabetic ulcers heal within 12 weeks (Zelen *et al.* 2017; Parks *et al.* 2020). This study could reveal that differences in wound healing among studies may be also influenced by the size, area of the wound, wound classification, treatments, age and pathological condition (Zimny, Schatz and Pfohl, 2002; Dinh, Elder and Veves, 2011; Yotsu *et al.* 2014; Monteiro-Soares *et al.* 2020; Parks *et al.* 2020) . No other study has evaluated the validity of an assessment scale to predict wound healing time in a period of 12 weeks typically in diabetic ulcers; therefore, the importance of distinguishing accurate scales for a given purpose was not compared. The results of this study will be considered in clinical practice for wound care management, particularly using the DMIST scale. In anticipation of progress in wound healing in the first 4 weeks (Oe *et al.* 2020) and up to 12 weeks, the DMIST scale will be useful in clinical settings. Assessment of wound progression using the DMIST scale should involve initial and ongoing wound assessment to provide basic wound progression information on which progress can be monitored and selection of correct dressings or treatment. Poor judgement in wound assessment can lead to improper wound management; therefore, it is important that the assessment is conducted according to the highest standards. If the clinician does not conduct the assessment properly, subsequent wound care will result in delayed healing (Greatrex-White and Moxey, 2015). It is expected that initial predictions of wound healing with a cutoff score of 9 will be a powerful predictor of future healing.

The small sample size used in this study is a limitation and the fact that other treatments or factors were not evaluated, for example, standard wound care, diabetic condition, type of diabetic ulcer and other conditions/treatments that may influence wound healing time. Further study will be continued with large sample and various types of wounds.

In conclusion, the cutoff DMIST score of 9 showed the best predictive performance in the clinical setting and is useful for predicting wound healing at 12 weeks in patients with diabetic ulcers.

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### Conflicts of Interest

The authors declare no conflict of interests.

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Table 1. Characteristics of respondents

Variables n (33)	
Age (median years)	54 (49–74)
Sex n (%)	
Female	25 (75.8)
Male	8 (24.2)
Neuropathy n (%)	
Negative	23 (69.7)
Positive	10 (30.3)
HbA1C level (median %)	9.50 (6–14)
ABI (median)	1.14 (0.70–1.40)
Systolic pressure (mean $\pm$ SD)	143.3 $\pm$ 31.17
Diastolic pressure (mean $\pm$ SD)	88.9 $\pm$ 17.14
Note: SD, standard deviation	

Table 2. Wagner classification and healing time

Wagner ulcer classification	Within 12 weeks n (%)	More than 12 weeks n (%)	Total
1	1 (100)	0 (0%)	1
2	16 (80)	4 (20)	20
3	6 (66.7)	3 (3.33)	9
4	0 (0%)	3 (100)	3
5	0 (0%)	0 (0%)	0

Table 3. Sensitivity and specificity of DMIST scores

Score	Sensitivity	Specificity
4	100	4
5	100	13
6	100	39
7	100	35
8	100	70
9	90	96
10	70	100
12	50	100
13	40	100
14	20	100
15	0	100

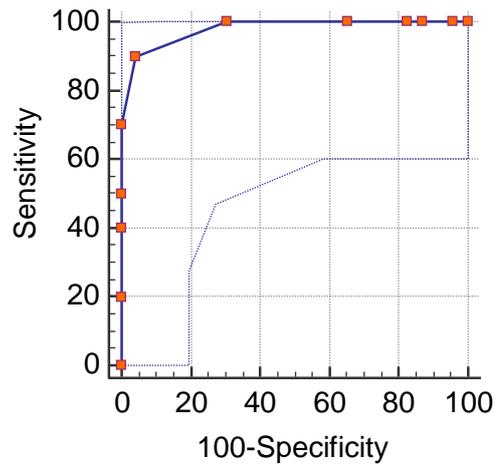


Figure 1. Receiver operating characteristic curves of DMIST score for wound healing within 12 weeks of follow-up (n = 33)