A Comparison of Two Diabetic Foot Ulcer Classification Systems

The Wagner and the University of Texas wound classification systems

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OBJECTIVE — In this study, the following two ulcer classification systems were applied to new foot ulcers to compare them as predictors of outcome: the Wagner (grade) and the University of Texas (UT) (grade and stage) wound classification systems.

RESEARCH DESIGN AND METHODS — Ulcer size, appearance, clinical evidence of infection, ischemia, and neuropathy at presentation were recorded, and patients were followed up until healing or for 6 months.

RESULTS — Of 194 patients with new foot ulcers, 67.0% were neuropathic, 26.3% were neuroischemic, 1.0% were ischemic, and 5.7% had no identified underlying factors. Median (interquartile range [IQR]) ulcer size at presentation was 1.5 cm^2 (0.6–4.0). Lower-limb amputations were performed for 15% of ulcers, whereas 65% healed [median (IQR) healing time 5 (3–10) weeks] and 16% were not healed at study termination; 4% of patients died. Wagner grade ($P < 0.0001$), and UT grade ($P < 0.0001$) and stage ($P < 0.001$) showed positive trends with increased number of amputations. For UT stage, the risk of amputation increased with infection both alone (odds ratio [OR] = 11.1, $P < 0.0001$) and in combination with ischemia (OR = 14.7, $P < 0.0001$), but not significantly with ischemia alone (OR = 4.6, $P = 0.09$). Healing times were not significantly different for each grade of the Wagner ($P = 0.1$) or the UT system ($P = 0.07$), but there was a significant stepwise increase in healing time with each stage of the UT system ($P < 0.05$), and stage predicted healing ($P < 0.05$).

CONCLUSIONS — Increasing stage, regardless of grade, is associated with increased risk of amputation and prolonged ulcer healing time. The UT system's inclusion of stage makes it a better predictor of outcome.

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Peripheral neuropathy is a common complication of diabetes, affecting >30% of the diabetic population (1). In the foot, peripheral neuropathy leads to dry skin and loss of the protective sensations of pressure and pain; together with reduced joint mobility (2), it also increases the risk of ulceration induced by unperceived minor injury from shoes and other physical trauma (3). The presence of macrovascular disease, possibly functional microangiopathy (4,5), and infection increases the probability of a foot ulcer leading to a lower-limb amputation (6).

Foot ulcers will occur in 5–10% of the diabetic population; up to 3% will have a lower-limb amputation (7). Ulceration is the most common precursor of amputation and has been identified as a component in more than two-thirds of lower-limb amputations (8). The presence or absence of infection and/or ischemia, footwear and pressure relief, and overall glycemic control influence the healing of ulcers (9). The depth of an ulcer is another important factor that affects the outcome of diabetic foot ulcers (10). Systematically recording these confounding factors is critical to planning treatment strategies, monitoring treatment effectiveness, predicting clinical outcomes, and improving communication among health care providers (11).

Various wound classification systems are used that attempt to encompass different characteristics of an ulcer (namely site, depth, the presence of neuropathy, infection, and ischemia, etc.) (12–18). It seems that poor clinical outcomes are generally associated with infection, peripheral vascular disease, and increasing wound depth; it also appears that the progressive cumulative effect of these comorbidities contributes to a greater likelihood of a diabetic foot ulcer leading to a lower-limb amputation. An easy-to-use classification system that provides a uniform description of an ulcer (including depth and presence of infection and ischemia) (19) will help in planning treatment strategies and predicting outcomes in terms of healing and lower-limb amputations.

The well-established widely used Wagner wound classification system (17) and the new University of Texas (UT) diabetic wound classification system (18) both provide descriptions of ulcers to varying degrees. Both wound classification systems are easy to use among health care providers, and both can provide a guide to planning treatment strategies.

The Wagner system assesses ulcer depth and the presence of osteomyelitis or gangrene by using the following grades: grade 0 (pre- or postulcerative lesion), grade 1 (partial/full thickness ulcer), grade 2 (probing to tendon or capsule), grade 3 (deep with

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Abbreviations: OR, odds ratio; UT, University of Texas; VPT, vibration perception threshold.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Baseline demography and foot ulcer characteristics in 194 patients*

Age (years)	56.6 ± 12.6
Sex (M/F)	149/45
Diabetes (type 1/type 2)	21/173
Duration of diabetes (years)	15.4 ± 9.9
Ulcer size (cm^2)	1.48 (0.68–4.0)
Type of ulcer (underlying factor)	
Neuropathic	130 (67.0)
Neuroischemic	51 (26.3)
Ischemic	2 (1)
Non-neuropathic, nonischemic*	11 (5.7)
Site of ulcer†	
Forefoot	151 (77.8)
Midfoot	23 (11.9)
Hindfoot	20 (10.3)

Data are *n*, *n* (%), means ± SD, or median (interquartile range). *The mean age (47.6 vs. 57.1 years, $P < 0.05$) and duration of diabetes (8.0 vs. 15.9 years, $P < 0.01$) of this group was much less than that of the rest of the group; †there were no differences in healing time or number of amputations among the different ulcer site groups ($P = 0.2$).

osteitis), grade 4 (partial foot gangrene), and grade 5 (whole foot gangrene). The UT system assesses ulcer depth, the presence of wound infection, and the presence of clinical signs of lower-extremity ischemia. This system uses a matrix of grade on the horizontal axis and stage on the vertical axis. The grades of the UT system are as follows: grade 0 (pre- or postulcerative site that has healed), grade 1 (superficial wound not involving tendon, capsule, or bone), grade 2 (wound penetrating to tendon or capsule), and grade 3 (wound penetrating bone or joint). Within each wound grade there are four stages: clean wounds (stage A), nonischemic infected wounds (stage B), ischemic noninfected wounds (stage C), and ischemic infected wounds (stage D).

The aim of this observational study was to determine which of the two wound classification systems, the UT or the Wagner, is a better predictor of outcome.

RESEARCH DESIGN AND METHODS

Study population and procedure

Diabetic patients who presented with a new foot ulcer to two specialist diabetic foot centers (Manchester, U.K., and San Antonio, TX) between 1998 and 1999 were enrolled into this observational study.

At presentation, the site of the ulcer was noted, and a photograph was taken. After wound debridement, the area of each ulcer was measured using a wound-mapping chart (3M Health Care, Loughborough, U.K.). Each ulcer was graded using both classification systems and staged using the UT system. Ulcers were labeled infected if a purulent discharge was present with two other local signs (warmth, erythema, lymphangitis, lymphadenopathy, oedema, pain). Wound depth was evaluated using a sterile blunt probe. The ability to probe to bone (20) with the presence of local or systemic infection and suggestive radiological features provided a clinical diagnosis of osteomyelitis. The diagnosis of lower-extremity vascular insufficiency was made clinically on the basis of absence of both pedal pulses of the involved foot and/or an ankle-brachial pressure index of <0.9 (21). The presence of significant sensory neuropathy was assessed using both the Biothesiometer (Biomedical Instruments, Newbury, OH) (22), to measure vibration perception threshold (VPT) at the tip of the great toe, and the simplified Neuropathy Disability Score (1,23,24). The diagnosis of clinically significant sensory neuropathy was made if the patient's VPT was >25 V and/or the neuropathy disability score was >6 of 10.

Patients initially were seen in the diabetic foot clinic on a weekly basis and were provided with the best possible care for their ulcers at each visit. To remove extensive callus and necrotic tissue, wound debridement was performed. After wound dressing, pressure relief was provided with either a scotchcast boot or a total contact cast. Broad spectrum antibiotics were prescribed if ulcers showed clinical signs of infection (growth factors were not used to enhance healing in this study). Patients with clinical evidence of ischemia had noninvasive ultrasound vascular studies and were seen by the vascular surgeon if necessary.

Patient follow-up was part of the normal treatment. Unhealed ulcers were followed up for a minimum period of 6 months. Once a patient's ulcer had healed completely or a lower-limb amputation was performed, the outcome was noted and the patient was deemed to have completed the study.

Statistical analysis

A χ^2 test for trend (χ^2_{trend}) was used to assess the trend association between increasing grade or stage and the prevalence of lower-extremity amputation (25,25a). To assess the potential association between stage and the number of amputations performed by the end of the study period, χ^2 analysis with odds ratio (OR) was performed. Kaplan-Meier survival analysis was used to estimate median healing times, and a log-rank test was used to compare healing times for different levels of grade or stage. Cox regression analysis was used to assess the ability of grade and stage to predict healing within the study period (25,25a). The 95% CI was calculated whenever appropriate, and statistical significance was defined as a *P* value <0.05. Statistical analysis was performed using SPSS for Windows, version 9.0 (SPSS, Chicago).

RESULTS — A total of 194 diabetic patients with recently diagnosed diabetic foot ulcers presented at the two specialist diabetic foot centers. Table 1 shows the baseline demographic details for the group of patients and baseline characteristics of their foot ulcers at first presentation. Eleven patients had no clinical evidence of moderate or severe neuropathy or vascular ischemia; when compared with the rest of the group, they were younger (47.6 ± 10.6 vs. 57.1 ± 12.6 years, $P < 0.05$) and had a shorter duration of diabetes (8.0 ± 4.5 vs. 15.9 ± 10.0 years, $P < 0.01$). The number of new foot ulcers and lower-limb amputations in each grade of the Wagner system and each grade and stage of the UT system are shown in Table 2. The main clinical outcomes for the 194 diabetic foot ulcers are shown in Table 3. Of all patients, 15% had lower-limb amputations as a result of their nonhealing ulcers, 65% had ulcers that healed completely, 4% (seven patients) died, and the remaining 16% had ulcers that still had not healed at study termination, despite a minimum follow-up period of 6 months. The percentages of patients

Table 2—*Foot ulcers, amputations, and unhealed ulcers in the Wagner grade and the University of Texas grade and stage*

	Foot ulcers (*n*)	Amputations (%)	Unhealed ulcers (%)
Wagner grade			
Grade 1	131	8	11
Grade 2	25	24	20
Grade 3	36	36	20
Grade 4	2	50	50
Grade 5	0	0	0
University of Texas grade and stage			
Stage A			
Grade 1	87	3	9
Grade 2	3	0	0
Grade 3	1	0	0
Stage B			
Grade1	12	17	0
Grade 2	14	14	14
Grade 3	25	40	20
Stage C			
Grade 1	18	17	17
Grade 2	4	0	25
Grade 3	0	0	0
Stage D			
Grade 1	14	14	29
Grade 2	8	50	25
Grade 3	8	50	38

who had clinically infected ulcers at presentation in each of the above groups were 80, 38, 57, and 19%, respectively. The patients who died were older at presentation compared with the rest of the group (70.4 ± 17.4 vs. 56.4 ± 11.0 years, $P < 0.05$). The deaths were due to myocardial infarction ($n = 3$), stroke ($n = 2$), pneumonia ($n = 1$), and septicemia as a result of an infected foot ulcer ($n = 1$). For the completely healed group (65% of patients), the median time taken for ulcers to heal was 5 weeks. There were no differences in the distribution of clinical outcomes between patients who were given scotchcast boots and those given total contact foot casts for pressure relief in this study ($\chi^2 = 0.04$, $P = 0.98$).

Wagner grade showed a significant positive trend with increased number of amputations ($\chi^2_{trend} = 21.0$, $P < 0.0001$). This was also true for both grade ($\chi^2_{trend} = 23.7$, $P < 0.0001$) and stage ($\chi^2_{trend} = 15.1$, $P = 0.0001$) of the UT system.

Using the UT stage, patients were 11 times more likely to undergo a lower-limb amputation if their ulcers were infected (stage B) when compared with clean nonischemic ulcers (stage A) (27.5 vs. 3.3%, $P < 0.0001$, OR = 11.1, 95% CI 3.0–41.0). Patients with noninfected ischemic ulcers (stage C) were five times more likely to undergo a lower-limb amputation when compared with stage A ulcers, but this did not reach statistical significance (13.6 vs. 3.3%, $P = 0.09$, OR = 4.6, 95% CI 0.9–24.7). However, when ischemic ulcers (with or without infection) were combined, patients with ischemic ulcers (stages C and D) were three times more likely to undergo amputation when compared with patients with nonischemic (stages A and B) ulcers (32.5 vs. 14.7%, $P < 0.05$, OR = 2.8, $\chi^2 = 6.1$, 95% CI 1.2–6.5). Patients with a combination of infection and ischemia (stage D) were 15 times more likely to undergo a lower-limb amputation when compared with patients with clean nonischemic ulcers (stage A) (33.3 vs. 3.3%, $P < 0.0001$, $\chi^2 = 21.2$, OR = 14.7, 95% CI 3.7–58.2).

Grade for the Wagner ($r = 0.26$, $P < 0.01$) and UT ($r = 0.26$, $P < 0.01$) systems both showed a weak positive correlation with ulcer healing time for the 65% of patients whose ulcers healed completely, but stage did not ($r = -0.06$, $P = 0.48$). Kaplan-Meier survival analysis showed no significant difference between median healing times in grades 1, 2, and 3 of the Wagner system (8, 16, and 11 weeks, respectively) ($\chi^2 = 5.68$, df = 3, $P = 0.13$) or median healing times in grades 1, 2, and 3 of the UT system (8, 12 and 16 weeks, respectively) ($\chi^2 = 5.47$, df = 2, $P = 0.07$). However, analysis showed that the median healing times (7, 11, 16, and 20 weeks) increased with each stage of the UT system ($\chi^2 = 10.24$, df = 3, $P = 0.02$). Cox regression analysis showed that only stage at presentation had a predictive effect on healing time ($\chi^2 = 10.3$, df = 3, $P < 0.05$). The higher the stage at presentation, the less likely it was for that ulcer to heal within the study period (hazard ratio 0.8, 95% CI 0.67–0.98, $P < 0.05$).

CONCLUSIONS — Few longitudinal studies have assessed the power of a foot ulcer classification system in predicting clinical outcome. This study not only performed this assessment for two commonly used classification systems, but also was the first to compare them as predictors of clinical outcome. The results of the study revealed that grade and stage affect the outcome of diabetic foot ulcers. The higher the grade, the greater the number of amputations performed. The trend for the UT grade was slightly greater than that for the Wagner grade.

As for stage, the presence of infection and/or ischemia increased the risk of

Table 3—*Clinical outcomes of 194 diabetic foot ulcers*

Outcome	Number of foot ulcers at presentation
Complete healing*	126 (65)
Amputation	30 (15)
Not healed	31 (16)
Patient death†	7 (4)

Data are *n* (%). *Median (interquartile range) healing time for the 65% of ulcers that healed was 5 (3–10) weeks. †The mean ± SD age for the patients who died during the study was greater than that for the rest of the group (70.4 ± 17.4 vs. 56.4 ± 11.0 years, $P < 0.05$).

amputation. Because of small numbers of patients in each group, the increased amputation risk seen with stage C did not reach statistical significance, but when regrouped, patients with ischemia (stages C and D) had higher risk of amputation compared with patients without ischemia (stages A and B). Previous studies have shown that infection and peripheral vascular disease are associated with an increased risk of amputation (26,27). In addition, only stage both showed a positive relationship with time to healing and predicted healing within the study period. It should be noted, however, that grading and staging were done at presentation only. Some patients may have had recurrent wound infection, which would prolong wound healing, and a few patients had revascularization procedures, which enhance wound healing. The HbA_{1c} level was not measured for all patients at presentation or at the same time point and therefore was not used for analysis. Additionally, only 6% of patients underwent revascularization before the end of the study. These confounding factors may have altered or undermined the expected effects of grade and stage at baseline on amputation rates and healing time.

The majority of deaths in this study were due to artherosclerotic vascular disease (myocardial infarction and stroke). Previous studies have assessed the effects of foot ulceration and osteomyelitis on morbidity and mortality in diabetic patients (28–31); such studies suggest that patients with foot ulcers have reduced quality of life and increased morbidity and mortality when compared with patients without foot ulcers. Another study has shown that diabetic patients with foot ulcers have a lower survival rate when compared with nondiabetic patients with foot ulcers (32). The increased mortality associated with diabetic foot ulcers seems to result from the additional comorbidity—an interesting finding that requires further investigation.

Patients who had no moderate or severe neuropathy may have had only mild neuropathy as a sufficient component cause with trauma and infection. The effect of diabetes on wound healing is another important factor that needs to be considered.

Wagner grade 4 and 5 ulcers were poorly represented in this study group, making it impossible to say if grades 4 and 5 add extra predictive power to the wound classification system. Gangrene is present in grades 4 and 5 and is usually due to a combination of ischemia and infection; these grades will, in most cases, have a similar outcome. Many of grade 4 and 5 patients go directly to the surgeons and are therefore not often seen by the diabetic foot team; ulcers in grades 4 and 5 of the Wagner system thus could be grouped together. Further studies are necessary to compare clinical outcomes of Wagner grade 4 and 5 ulcers with that of UT grade 3, stage D—an argument that makes the UT system appear simpler and more practical.

An infected ischemic ulcer that penetrates to tendon (grade 2, stage D, or, simply, grade 2D of the UT system) alternatively will be grade 2 of the Wagner system. A labeling of grade 2 of the Wagner system thus will not alert other members of the foot care team of the presence of infection and ischemia, which can prolong wound healing and increase the risk of lower-limb amputation. The addition of stage to grade improves the descriptive and predictive power of a wound classification system, especially for ulcers within the same grade.

The UT system, which combines grade and stage, is more descriptive and shows a greater association with increased risk of amputation and prediction of ulcer healing when compared with the Wagner system. Therefore, for groups rather than individual patients, the UT system, which is simple and easy to use, is a better predictor of clinical outcome.

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