Comparison of Two Smartphone Applications in the Assesment of Diabetic Foot Wound as an Alternative Telemedicine in H. Adam Malik Hospital, Medan

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Abstract

Introduction: The high incidence of diabetic foot ulcers has prompted the development of various approaches for objective measurement of wound size that have been suggested. The focus in recent decades has been on two-dimensional methods of measuring wound area, which can be divided into contact and non-contact methods. The use of telemedicine has benefits because it is cost-effective, improves health outcomes, and encourages patient satisfaction who need care, especially patients with chronic diseases such as type 2 diabetes mellitus. The use of smartphone applications is highly desirable for use in the assessment of diabetic foot wounds.

Methods: This research is an observational analytic study with a cross-sectional design. The data was collected from March 2023 to April 2023, with a total sample of 54 people who fit the inclusion criteria. To analyze the differences, a paired T-test will be used if the data is normally distributed or Mann-Whitney if it is not normally distributed.

Results: Manual examination showed an average wound length x width of 4.45±2.34 cm (1.55 cm-8.15 cm) x 3.11±1.57 cm (1.2 cm-5.48 cm). The Imito application examination showed an average wound length x width of 4.83±1.94 cm (1.72 cm-7.95 cm) x 3.37±1.36 cm (1.22 cm-5.30 cm). The Wound Measurement application examination showed an average wound length x width of 4.51±2.37 cm (2.01 cm-8.60 cm) x 3.18±1.44 cm (1.9 cm-6.17 cm).

Conclusion: Assessment of wound measurements using the Wound Measurement application is closer to manual measurements when compared to the Imito application.

Keywords: smartphone application, wound assessment, diabetic ulcer wound

I. INTRODUCTION

Surgical debridement is the fastest and most efficient method of removing necrotic and dead tissue. Particular attention should be paid to separating dead tissue from healthy tissue. Postoperatively, patients should be closely monitored and educated to monitor the condition of their feet and use appropriate footwear(Marina et al., 2019). Ignorance of the presence of foot ulcers, underestimating their significance, and lack of access to appropriate professional wound care are factors associated with the delayed presentation of diabetic foot cases. Another qualitative study also suggested factors associated with delayed presentation of diabetic foot complications. Various approaches to objective measurement of wound size have been suggested. The focus in recent decades has been on two-dimensional methods for measuring wound area, which can be divided into contact methods (e.g., manual and digital planimetry) and non-contact methods (e.g., simple ruler method, mathematical models such as ellipses (Chithambo & Forbes, 2015; Perera et al., 2013; Rouyard et al., 2017).

The simple ruler method multiplies the length and width of the largest wound to determine the surface area. This is a low-cost and easy-to-use method. However, it is accurate only on perfectly rectangular wounds and does not account for wound irregularities. Thus the possibility of exaggerating the area. (Wang et al., 2017). Smartphones with high-definition digital cameras are now widely available and relatively cheap. The high portability and mobility provided by the device are very attractive for clinical applications. Imito and other smartphone-only apps have emerged to make wound measurement and documentation easier and simpler. The limit application is a non-contact digital planimetry application, giving it an advantage over other methods(Wang et al., 2017).

In previous studies, differences between applications were not identified as significant. Considering that all measurements are based on photographic position and adequate calibration, several points must be considered when photographing wounds. First, the QR code must be positioned parallel to the wound. This approach avoids underestimating or exaggerating the wound area. Second, the image must be taken directly from the wound, avoiding axis deviation. In another study, a deviation of the wound optical axis of 20 degrees led to an underestimation of the surface by 10%. Third, the image must be positioned and sized on the smartphone screen to fill the entire surface(Biagioni et al., 2021).

Area manual setting in the Imito app is obtained by tracing the circumference with a point-to-point line. With a magnified image, the distance between the points will be smaller, increasing the wound's outline. Considering such an orientation, in another study, the researchers observed that relatively untrained professional medical photographers and physician photographers were similar in area measurements. (Fang et al., 2021). Telemedicine is the delivery of healthcare services remotely using electronic means for diagnosing, treating, preventing disease and injury, research and education, and educating healthcare providers. The use of telemedicine has benefits because it is cost-effective, improves health outcomes, and encourages satisfaction of patients who need care, especially patients with chronic diseases such as type 2 diabetes mellitus and cancer. Therefore, smartphone applications are highly expected to be used in the assessment of diabetic foot wounds.

II. Methods

This type of research is observational analytic with a cross-sectional design. Data collection is taken from primary data to record a comparison of manual measurements with the use of smartphone applications to assess diabetic foot wounds as an alternative to telemedicine at H. Adam Malik General Hospital Medan. This research was conducted with the approval of the USU FK Research Ethics Commission. Research and data collection will be carried out from March 2023 to April 2023, followed by processing and analysis of the data that has been collected.

The population in this study were patients with diabetic foot ulcers who were treated either conservatively or surgically at Adam Malik Haji Center General Hospital Medan. While the research sample was taken using the total sampling method, where the sampling technique is the same as the population. The inclusion criteria in this study were patients aged 18-60 years diagnosed with diabetic foot ulcers clinically and laboratory examination, treated at outpatient and inpatient polyclinics at H. Adam Malik General Hospital Medan. They agreed to participate in the study and signed informed consent. Exclusion criteria in this study were diabetic foot ulcers that were impossible to measure in two dimensions without clear boundaries and diabetic foot ulcers accompanied by other traumatic injuries.

Patients with diabetic foot ulcers will be anamnesis, and a physical examination will be conducted to collect data regarding age, gender, and education. Furthermore, data was taken regarding measuring the area of diabetic foot ulcers in length, width, area, and depth with manual calculations using the Imito Measure application and the Wound Measurement application by Readers 1 and 2.

Two readers will read all data and test the results using the Kappa Test. A kappa value > 0.8 is declared good, and then the data will be analyzed according to the research objectives. The data will be analyzed descriptively to determine the frequency distribution based on the characteristics. The data will then be displayed in percentage values. To analyze the differences, a paired T-test will be used if the data is normally distributed or Mann-Whitney if it is not normally distributed.

III. Results

This research is an observational analytic study with a cross-sectional design. Data collection was taken from primary data to record comparisons of the use of smartphone applications for assessing diabetic foot wounds as an alternative to telemedicine at H. Adam Malik General Hospital Medan. Research and data collection were conducted from March 2023 to April 2023, with a total sample of 54 people who fit the inclusion criteria.

Table 1. Frequency Distribution of Research Respondents (n=54)

Characteristics		
Age		
Mean±SD (Min-Max)	53.20±8.397 years (42-67 years)	
Gender (n, %)		
Man	30	55.6%
Woman	24	44.4%
Education (n, %)		
Junior High School	6	11.1%
Senior High School	27	50.0%
Undergraduate	21	38.9%

Table 1 shows that the mean age of the patients was 53.20 years with a standard deviation of 8,397 years, within the range of 42 years to 67 years. The most common gender was male, with 30 people (55.6%), and women, with 24 people (44.4%). The most recent education found were high school graduates with 27 people (50%), bachelor graduates with 21 people (38.9%), and junior high school graduates with six people (11.1%).

Table 2. Measurement Reliability Analysis with Intraclass Correlation Coefficient (ICC) between Readers and Measurement Methods

Measurement Method	**Parameter**	***Intraclass Correlation Coefficient*(ICC)**
Manuals	Length	0.998
	Width	0.996
Mito application	Length	0.842
	Width	0.850
	Width	0.816
	Diameter	0.888
Wound Measurement Application	Length	0931
	Width	0962
	Depth	0.434

Two readers read all data and then tested the results using *Intraclass Correlation Coefficient* (ICC). Values > 0.8 are declared good, and then the data will be analyzed according to the research objectives. The ICC results of the three measurement methods from two readers show that manual measurement has the highest ICC value among readers, namely 0.998, then the Wound Measurement application, which is 0.931, and the Imito application, which is 0.850, which can be interpreted that the results of these measurements are reliable, as shown in Table 2.

Table 3. Distribution of Diabetic Foot Wound Sizes based on Measurement Methods and Wound Length

Measurement Method	Parameter	Mean+SD (Min-Max)
Manuals	Length	4.45±2.34cm (1.55cm-8.15cm)
	Width	3.11±1.57cm (1.2cm-5.48cm)
Mito application	Length	4.83±1.94cm (1.72cm-7.95cm)
	Width	3.37±1.36cm (1.22cm-5.30cm)
	Area	13.04±9.98 cm2 (1.37 cm2-30.62 cm2)
	Circumferences	13.37±5.46 cm2 (4.56 cm2-21.49 cm2)
Wound Measurement Application	Length	4.51±2.37cm (2.01cm-8.60cm)
	Width	3.18±1.44cm (1.9cm-6.17cm)
	Depth	0.39±0.76cm (0cm-2.70cm)

Table 3 shows where the comparison between manual inspection and the Imito application on the length parameter is 0.420, and the width is 0.225, which tends to be lower than the comparison between manual inspection and the Wound Measurement application with the length parameter being 0.858 and the width parameter being 0.382. From these results, it can be concluded that the assessment of wound measurements using the Wound Measurement application is closer to manual measurements when compared to the Imito application.

Table 4. Differences in Wound Study Results based on Measurement Methods in Diabetic Foot Wound Patients

Comparison of Measurement Methods	Measurement Parameters	p-value*
Manual with the Imito App	Length	0.420
	Width	0.225
Manual with Wound Measurement Application	Length	0.858
	Width	0.382

*Mann-Whitney test

Table 4 shows that there is no significant difference between the results of wound studies based on the measurement method in patients with diabetic foot wounds.

IV. Discussion

Wound care begins with wound assessment, which involves accurate measurement of parameters such as wound area, depth, volume, stage, signs of infection, and healing potential. The majority (94.1%) of the included studies focused on wound assessment and documented the effectiveness of various systems in measurement accuracy and precision in diabetic foot ulcers. The use of computer software and handheld devices has shown optimistic results (Howell et al., 2021). Previous studies reported low inter-observer variability in computer applications in digital wound area measurements (ICC > 0.99 and inter-observer variability of 15.9%, respectively). This is very important in monitoring diabetic foot ulcers because the management of diabetic foot ulcers involves a multidisciplinary team. It is critical for low interobserver variability for proper documentation to track wound progress or healing and institute appropriate management (Howell et al., 2021; Barakat-Johnson et al., 2022).

The results of this study showed that the average age of the patients was 53.20 years with a standard deviation of 8.397 years, in the range of 42 years to 67 years. The most frequently found gender were men with as many as 30 people (55.6%) and women with as many as 24 people (44.4%). Previous studies showed that 61% of diabetic foot ulcer patients were male, with 38.9% female. The mean age of the patients was 59.61 years, with an age range of 39 to 72 years (Boulton et al., 2018).

Previous research has shown that the average age of men and women with type 2 diabetes is 53 and 49 years, respectively. Current data indicates that women are at risk of developing diabetes at an earlier age than men. Peripheral arterial disease and peripheral neuropathy are complications of diabetes that predispose to foot ulcers, 6.68% of subjects were found to have peripheral arterial disease, and 26% were identified with peripheral neuropathy. Peripheral neuropathy is a major factor contributing to the risk of foot ulcers in people with diabetes; these results are consistent with previous reports emphasizing the importance of peripheral neuropathy of the foot (Suh et al., 2016; Boulton et al., 2018).

The most recent education found were high school graduates with 27 people (50%), bachelor graduates with 21 people (38.9%), and junior high school graduates with six people (11.1%). Previous research showed that 60% of patients with diabetic foot ulcers were undergraduates, followed by high school at 20%, junior high school at 13.3%, and elementary school at 6.7%. Level of education is important in how patients seek treatment for their diabetic foot ulcers. This finding is in line with research conducted by previous studies, which showed that education increased cases of adherence to diabetic foot care. Another study also found the same thing about the effect of health education on knowledge in preventing diabetic foot ulcers, with a total of 54 respondents. The patient's tendency to treat

diabetic foot ulcers also increases length with the knowledge they have (Marina et al., 2019; Ali Shaikh, Masood Siddiqui, and Hameed Shaikh, 2021).

Another study found that having sufficient knowledge about patients was 2.38 times more likely to practice foot care. This study concluded that knowledge gained through case education contributes to preventing diabetic ulcers. Increased knowledge through health education conducted by nurses significantly helps patients and their families to obtain additional information about their disease and how to deal with it until they recover. Previous studies have also found that factors related to patient adherence to self-care include family support, individual preferences, patient conception, and social and cultural activities. Other studies also report that family support positively affects health behavior (Baig et al., 2022; Chan et al., 2022).

This study found that the ICC results of the three measurement methods from two readers showed that manual measurement had the highest ICC value among readers, namely 0.998, then the Wound Measurement application, which was 0.931, and the Imito application, which was 0.850, which could be interpreted that the measurement results were reliable. Previous studies that assessed the application of Imito and ImageJ in assessing diabetic ulcers showed that the ICC between ImageJ and Imito was 0.978 for a single size and 0.989 for the average size. The 95% confidence interval (CI) is 0.983 to 0.993 (P < 0.0001) (Biagioni et al., 2021; Fang et al., 2021).

Previous studies described high accuracy of ≥95.75% and ≥94.62% in determining wound length, width, and area, respectively, using fluorescence imaging. Previous studies described using an optical imaging marker with low intra-operator variability of 3.3% but with a concordance of only >50% for all questions on a standard wound assessment form at all assessments.(Biagioni et al., 2021). Regarding the size distribution of diabetic foot wounds based on the method of measurement and the length of the wound, this study shows that the results of manual examination mean the length x width of the wound is 4.45±2.34 cm (1.55 cm-8.15 cm) x 3.11±1.57 cm (1.2 cm-5.48) cm). The Imito application examination showed an average wound length x width of 4.83±1.94 cm (1.72 cm-7.95 cm) x 3.37±1.36 cm (1.22 cm-5.30 cm). The Wound Measurement application examination showed an average wound length x width of 4.51±2.37 cm (2.01 cm-8.60 cm) x 3.18±1.44 cm (1.9 cm-6.17 cm).

Previous studies have shown that the average wound area is 12.20±10.45 cm^2 for Imito and 12.67+10.86 cm^2 for ImageJ. The difference in the mean area measured using ImageJ and Imito is 0.47 cm^2 (3.71% greater using ImageJ). According to the t-test (p-value = 0.121), the two groups had no significant difference. The average area by the same observer using Imito is 12.23±10.7 cm^2 and 12.28±10.91 cm^2. Comparing these means, statistically, no difference was identified (t-test; P=0.847), and ICC showed very good interobserver correlation using Imito (ICC, 0.987; 95% CI, 0.878–0.999). The average area of the two measurements with ImageJ is 12.65±10.89 cm2 and 12.68±11.07 cm^2. There is no difference between the mean values identified using the t-test (P = 0.480), and ICC is 0.999 (95% CI, 0.999-1.000). The two measurements by the same observer using the ImageJ method have a very good correlation (Biagioni et al., 2021; Fang et al., 2021).

This study looked at differences in the results of wound studies based on measurement methods in diabetic foot wound patients, where the comparison between manual examination and the Imito application on the length parameter, namely 0.420, and width, namely 0.225, tends to be lower compared to the comparison between manual examination and the Wound Measurement application with the length parameter, namely 0.858 and the width parameter is 0.382. From these results, it can be concluded that the assessment of wound measurements using the Wound Measurement application is closer to manual measurements when compared to the Imito application.

Previous studies have shown that when analyzing differences in different area measurements, the 9 cm^2 cutoff reveals a large difference between the two methods (4.28% and 1.17% greater using ImageJ for images with superior and inferior areas up to 9 cm^2). Considering the use of different smartphone operating systems, the region does not differ between Imino and ImageJ. The ICC comparing the results is 0.995 for iOS (95% CI, 0.991-0.997) and 0.970 for Android (95% CI, 0.946-0.984). However, the difference between measurements is larger for Android than iOS systems. For iOS, the difference is 1.15% between ImageJ and Imito (P = 0.357) and 5.60% for Android (P value = 0.084) (Nejati et al., 2016; Biagioni et al., 2021; Fang et al., 2021).

Smartphones with high-definition digital cameras are now widely available and relatively cheap. The high portability and mobility provided by the device are very attractive for clinical applications. Imito and other smartphone-only apps have emerged to make wound measurement and documentation easier and simpler. The limit application is a non-contact digital planimetry application, giving it an advantage over other methods. In this study, differences between raters were not identified significantly. Considering that all measurements are based on photographic position and adequate calibration, several points must be considered when photographing wounds. First, the QR code must be positioned parallel to the wound. This approach avoids inaccurate measurements or overstating the wound area (Nejati et al., 2016).

V. CONCLUSION

The average age of the patients was 53.20±8.397 years, in the range of 42-67 years, with the most common gender being male (55.6%) and the most recent education found being high school graduates (50%). Manual examination showed an average wound length x width of 4.45±2.34 cm (1.55 cm-8.1 cm). The Imito application showed an average wound length x width of 4.83±1.94 cm (1.72 cm-7.95 cm) x 3.37±1.36 cm (1.22 cm-5.30 cm). The Wound Measurement application examination showed an average wound length x width of 4.51±2.37 cm (2.01 cm-8.60 cm) x 3.18±1.44 cm (1.9 cm-6.17 cm). Assessment of wound measurements using the Wound Measurement application is closer to manual measurements when compared to the Imito application

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