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3D-Wound Imaging: Precise, Consistent, and Efficient

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DOCTOR OF NURSING PRACTICE

3D-Wound Imaging: Precise, Consistent, and Efficient

by

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Table of Contents

List of Tables

List of Figures

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3D-Wound Imaging: Precise, Consistent, and Efficient

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Abstract

Background: The most common method of obtaining wound measurements is the hand-ruler method. Studies show that the hand-ruler method results in the most inaccurate measurements with the lowest interrater reliability. Studies also show that using 3D-wound imaging yields the most accurate measurements with the best interrater reliability. 3D-wound imaging technology also increases efficiency by allowing users to obtain images and document assessments using one device at the bedside.

Purpose: The purpose of this project is to make the process of assessing wounds more efficient by decreasing the time spent on photographing, measuring, and documenting wound assessments by implementing the use of 3D-wound imaging technology and software.

Methods: Prior to the implementation of the 3D-wound technology, a baseline time of completing skin rounds assessments of wounds including imaging, measuring, and documentation was obtained via questionnaire asking nurses the average time they have experienced in completing all skin rounds duties including imaging, assessing, and documenting wounds. During implementation of 3D-wound imaging, start and end times were obtained through the 3D-wound software reporting dashboard. Other information collected included the number of wounds and number of patients that were seen. Post implementation data was analyzed 2-months after implementation.

Evaluation/Results: After 2 months, the results showed a decrease in time to image wounds, conduct a full assessment and complete documentation by an average of 4.73 hours or 59%. Implementation of 3D-wound technology also allowed for realignment of the skin rounds team and decrease the number nursing personnel required on the team.

Implications for Practice: Streamlining the process of wound assessment and documentation by implementing the use of 3D-wound imaging technology can be rolled out to the entire hospital, including outpatient clinics. A more widespread use of the technology can lead to decreased manhours across the facility and therefore decreased costs.

Conclusion: Future studies can show how clinicians use the accurate data provided by the 3D-wound imaging device in making treatment decisions which can ultimately lead to faster healing and decreased hospital bed days.

3D-Wound Imaging: Precise, Consistent, and Efficient

Wounds are a major health problem that can be costly to both the patient and facility. Nussbaum et al., conducted a retrospective study of 2014 Medicare data that showed that 14.5% of Medicare beneficiaries were diagnosed with at least one type of wound or wound infection including surgical wound infections, abscesses, cellulitis, and nonhealing wounds. The total Medicare spending estimates for all types of wounds in 2014 range from $28.1 billion to $96.8 billion (2018). The proper treatment of a wound is guided by the measurements of the wound that show progress, stagnation, or worsening. In order to appropriately monitor the healing process of a wound, it is necessary that accurate and consistent measurements are obtained. Providing clinicians with accurate wound measurements aid in treatment decisions that improve the care of patients with wounds (Shah, Wollak, & Shah, 2015). The traditional and most used practice of wound measuring is manually using disposable rulers to obtain the length, width, and depth of each wound which has shown to have low inter-rater reliability (Chaby et al., 2017). With advancements in 3D-wound imaging technology and software, clinicians have greater wound measurement options that has proven accuracy and high inter-rater reliability. The newer 3D-wound imaging systems have also been made to be more portable and user friendly that has increased efficiency in wound assessments (Malone et al., 2020).

Background and Evidence

An initial literature search was done to view any articles about 3D-wound imaging in general using the title search “three-dimensional wound imaging” in the PubMed database within the past five years. This yielded seven articles. The same search was conducted in the CINAHL database and yielded six articles, one of which pertained to 3D-wound imaging that did not appear in the PubMed search. Similar search processes were used in other databases, including

Google Scholar. Many of the studies compared different wound measuring techniques including hand-ruler, 3D-wound imaging, and planimetry. A summary of the studies has been comprised into a table in Table 1.

Table 1

Major Related Studies: Summarized Literature Evaluation Table

Citation: (i.e., author(s), date of publication, & title)	Purpose of Study	Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Worth to Practice Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses]) Feasibility conclusion RECOMMENDATION
Chaby, G., Lok, C., Thirion, J. P., Lucien, A., & Senet, P. (2017). Three-dimensional digital imaging is as accurate and reliable to measure leg ulcer area as transparent tracing with digital planimetry. *Journal of Vascular Surgery: Venous and Lymphatic Disorders*, *5*(6), 837–843. https://doi.org/	Investigate if digital 3D-wound imaging system could be considered a suitable alternative to transparent wound tracing for measurements	Digital 3D-wound imaging is comparable to transparent tracing of venous leg ulcers	Prospective multicenter cohort study	Outpatients 18 years or older with one or more venous leg ulcers	-IV1 = 3D device -IV2 = transparent tracing -DV = wound measurement	Target wound area	SAS software version 9.3	-CCC close to 1 indicuating good agreement and correlation between digital imaging method and transparent tracing method -Inter-rater reliability CCC at 0.926 indicating both methods were equivalent in measuring changes in venous leg ulcer area over time	-LOE = prospective cohort -Limitations = study only included one type of wound in a specific area of the body -No risk or harm if study intervention or findings implemented -Feasible to implement in my practice -Conclusion = 3D-wound imaging is consistent with transparent tracing method of venous leg ulcers and has a high interrater reliability -Can use evidence to show 3D-wound measurement accuracy -Recommend including other wound types in future study

10.1016/j.jvsv.2017.05.019									
Darwin, E. S., Jaller, J. A., Hirt, P. A., & Kirsner, R. S. (2019). Comparison of 3-dimensional Wound Measurement With Laser-assisted and Hand Measurements: A Retrospective Chart Review. *Wound Management & Prevention, 65* (1), 36–41. doi: 10.25270/wmp.2019.1.3641	Test 3D WMD against hand measurement methods	Hand measurements are inaccurate and 3D WMD give most accurate data	Retrospective comparative analysis	Patient records from outpatient wound healing clinic who had wound measured using the 3 different methods at one visit	-IV1 = 3D device -IV2 = laser -IV3 = hand measurement -DV = wound measurement	Wound area	SPSS Statistics; Bland-Altman plot; paired t testing	-Avg abs diff between IV1 and IV2 = 0.33 cm^2 (3.88%) -Avg abs diff between IV1 and IV3 = 4.74cm^2 (32.55%) -Avg abs diff between IV2 and IV3 = 4.60cm^2 (32.79%) -Paired t test between IV1 and IV2 → *P* = 0.340 -IV1 and IV3 → *P* = 0.008 IV2 and IV3 → *P* = 0.006	-LOE = controlled cohort study -Strengths = good reliability of 3D device -Limitations = retrospective design, small sample size; use of Bland-Altman plot only looks at agreement between 2 measurement techniques -No risk or harm if study intervention or findings implemented -Feasible to implement in my practice -Conclusion = 3D imaging is more accurate. Hand measurements overestimate wound area -Can use evidence to prove use of 3D measurements are more accurate -Recommend to test 3D WMD against other 3D WMDs
Malone, M., Schwarzer, S., Walsh, A., Xuan, W., Al Gannass, A., Dickson, H.	Examine what 3D-wound measurements yield the most	3D-wound technology gives clinicians more data,	Prospective pilot study	21 diabetic foot ulcers	-IV1 = 3D wound technology	Wound area, planimetry area, surface area, planar volume,	Linear regression and Pearsons correlation coefficient,	-Linear healing slope = > R 0.70 and statistical significance p = 0.0001	-LOE = prospective pilot study -Strengths = 3D-imaging system used in study previously validated against traditional hand-measured measurements

G., & Bowling, F. L. (2020). Monitoring wound progression to healing in diabetic foot ulcers using three-dimensional wound imaging. *Journal of Diabetes and Its Complications*, *34*(2), 107471. https://doi.org/10.1016/j.jdiacomp.2019.107471	reflective marker of wound healing	but no studies have shown what data is most useful in determining healing			-DV = wound measurement	curved volume	intra-class correlation coefficients	-Low variability between users	-Limitations = only looked at diabetic foot ulcers -No risk or harm if study intervention or findings implemented -Able to use in practice -Can use evidence to show most useful 3D-wound measurements in assessing wound healing -Recommend including other wound types in future studies
Nussbaum, S. R., Carter, M. J., Fife, C. E., DaVanzo, J., Haught, R., Nusgart, M., & Cartwright, D. (2018). An economic evaluation of	Determine cost of care of chronic wound care for Medicare beneficiaries	High cost of wound care	Retrospective analysis	2014 Medicare database	-IV1 = wound prevalence -IV2 = wound type	Prevalence, associated cost	Prevalence = ICD 9 on Medicare claims data Cost = low range estimate calculated Medicare	-Prevalence = 14.5% Medicare beneficiaries -Types -Surgical wound infection = 4.0 -Diabetic wound infection = 3.4%	-LOE = retrospective analysis -Strength = comprehensive study of Medicare spending on wound care and inclusion of ICD 9 codes -Limitations = estimates of wound prevalence are subject to considerable uncertainty

the impact, cost, and Medicare policy implications of chronic nonhealing wounds. Value in Health, 21(1), 27–32. https://doi.org/10.1016/j.jval.2017.07.007					-DV = wound care cost		provider payments when wound was primary diagnosis; midrange estimate calculated entire payment of claim to wound care if wound diagnosis was primary diagnosis; high range calculated when wound was either primary or secondary diagnosis and provided upper bound estimate to total	-nonhealing surgical wound = 3.0% -Other = 0.1% - 2.7%	-No risk or harm if study intervention or findings implemented -Able to use in practice -Wound management is financially costly -Can use study to show how much wound care costs based on just Medicare beneficiaries -Further research can be done to see how data can be used to develop more accrurate quality measures and reimbursement models

							spending associated with wound care		
Yen, P. Y., Kellye, M., Lopetegui, M., Saha, A., Loversidge, J., Chipps, E. M., Gallagher-Ford, L., & Buck, J. (2018). Nurses' Time Allocation and Multitasking of Nursing Activities: A Time Motion Study. *AMIA ... Annual Symposium proceedings. AMIA Symposium*, *2018*, 1137–1146.	Observe nursing activities during shift as it relates to higher quality care and best outcomes	Nurses spend time on non-nursing activities that can be sed more effectively for patient care	Observational study	1 med-surg unit at a Mid-west academic medical center	-IV1 = nursing activity -DV = time spent on each activity	Descriptive analysis	R to perform Wilcoxon test; non-parametric independent-samples Krukal-Wallis test; SPSS Statistics 25	-Nurses spent 35% time in patient room -25% time on documentation	-LOE = observational time motion study -Strength = quantified and compared nurses' time allocation in different time blocks -Limitations = observations only done during dayshift -No risk or harm if study intervention or findings implemented -Able to use in practice -Can use study to show distribution of nursing activities and how much is spent on non-nursing tasks or charting -Future studies can include other observation times

Problem

Studies have shown that nurses spend 26.2% - 41% on documentation. Streamlining processes and creating more efficient workflows can aid in decreasing nursing time spent on documentation or other non-nursing duties and allow more time for nurses to work at the top of their license for high quality care and best outcomes (Yen et al., 2018).

In a Southern California Spinal Cord Injury (SCI) unit, it was found that the skin rounds team conducts full assessment of all wounds on the unit once a week and includes obtaining images, wound measurements, and documentation of assessments in the electronic health record (EHR). The skin rounds team took an average of 8 hours to take images of all wounds using a digital camera, obtain wound measurements using the hand-ruler method, and chart assessments and upload images to the EHR.

The following clinical question was posed, including the population, intervention, comparison, outcome, and time: In a Southern California Spinal Cord Injury Unit, does implementing the use of 3D-wound technology to obtain pictures, automatic measurements, and complete documentation compared to using a digital camera, traditional hand-ruler technique, and documenting in the EHR at a later time result in increased efficiency and decreased time for the skin rounds team to complete assessments of all wounds by 30% in a 2-month period?

Purpose and Scope

The purpose of this study is to introduce new technology to the unit which can aid in creating a more efficient process for wound assessments. 3D-wound technology will allow for obtaining images, automatic measurements, and complete documentation on one device at the bedside.

EBP Model

There are numerous models and theories that exist that aid in implementing evidenced-based practices. The Iowa Model of Evidenced-Based Practice to Promote Quality Care will help in translating research findings into clinical practice by combining quality improvement with research utilization. The first step in the Iowa Model is to identify a trigger. A trigger can either be problem-focused where there is an issue found in a current practice and there is opportunity for improvement or knowledge-focused where new research findings are presented that challenge current practice standards. The next step in the model is to identify if the topic is a priority for the organization. If so, then a team is formed to develop, implement, and evaluate the practice change. (Melnyk and Fineout-Overholt, 2019). The problem-focused trigger found in the SCI wound assessment process is using outdated technology and methods which are time consuming. In the SCI unit, where majority of the patients are admitted for wounds, any best practice involved with the caring and treating of wounds is a priority. Forming a team was essential in the successful acceptance and implementation of this evidenced-based practice (EBP) change. Having frontline clinicians on the team voicing the need for change will be more widely accepted by others than if the change was directed purely by management. If the team also involves the nurse manager, then this will help in gaining buy-in from upper management and executive leadership. Another step of the Iowa Model that was beneficial in implementing this EBP change was piloting the change. At this point, the change was conducted in a smaller environment and issues were easily identified. This allowed for modification of the practice guidelines prior to a larger scale rollout of the change.

Project Implementation

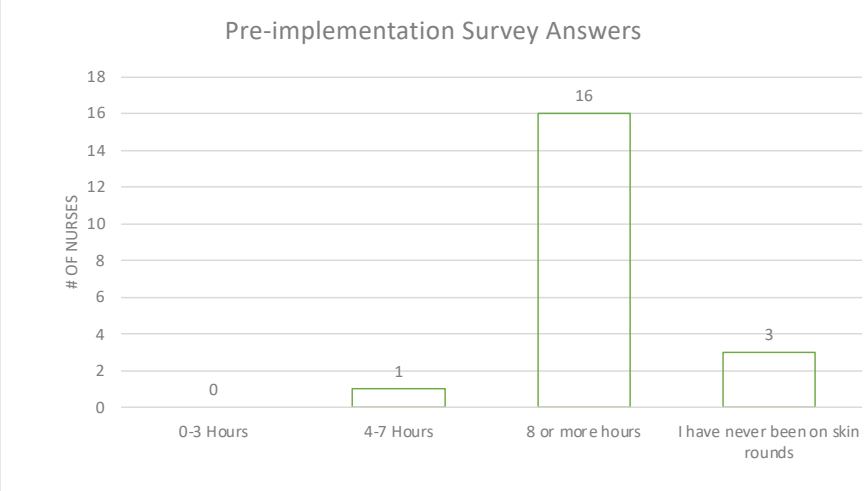
3D-wound technology hardware and software subscription were procured through the Office of Connected Care (OCC). Bi-weekly meetings were held with the SCI wound care nurse and 3D-wound software developers to review and edit workflows prior to full implementation on the unit. IRB excusal was obtained from the VA San Diego Medical Center in June 2022 and from the University of San Diego in August 2022. Nursing staff competency checklist was reviewed and approved by the SCI Clinical Nurse Specialist in April 2022. Multiple staff in-services and training on using the 3D-wound imaging device was provided in June 2022. One-on-one hands-on training was also provided throughout June 2022. The skin rounds team began using the 3D-wound device exclusively for weekly wound assessments on the unit in July 2022.

Evaluation Results

Pre-implementation time data was obtained through survey asking, “What is the average length of time you have spent on skin rounds to complete all wound imaging and uploading, obtaining wound measurements, and documenting wound assessments?”. Figure 1 shows that 16 of the 20 staff surveyed answered 8 or more hours.

Figure 1

Pre-implementation Survey of Skin Rounds Time



After implementation, a total of 8 skin rounds were completed from June 2022 – August 2022. Different data points were collected automatically by the 3D-wound software and obtained through the software's check-in reports dashboard. Data collected on each skin rounds included start time, end time, number of patients seen, and number of wounds assessed (Table 2). Table 3 shows the average time needed to complete skin rounds, the average number of patients seen, and the average number of wounds assessed each month. Figure 2 compares pre-implementation data to post-implementation data and shows a decrease in time needed to complete skin rounds from 8 hours to 3.32 hours in July and 3.22 hours in August. This is an average decrease in time by 4.73 hours, or 59%.

Table 2

Skin Rounds Start and End Time, Total Patients, and Total Wounds

Date	Start time	End time	Total Hours	Total Patients	Total Wounds
7/5/22	8:21	11:47	3:26	10	20
7/12/22	8:14	12:42	4:28	12	22
7/19/22	9:29	11:38	2:09	9	17
7/26/22	8:19	11:35	3:16	10	26
8/2/22	8:30	11:17	2:47	9	18
8/16/22	8:23	12:10	3:47	10	21
8/23/22	8:31	11:54	3:23	11	22
8/30/22	8:23	11:19	2:56	13	29

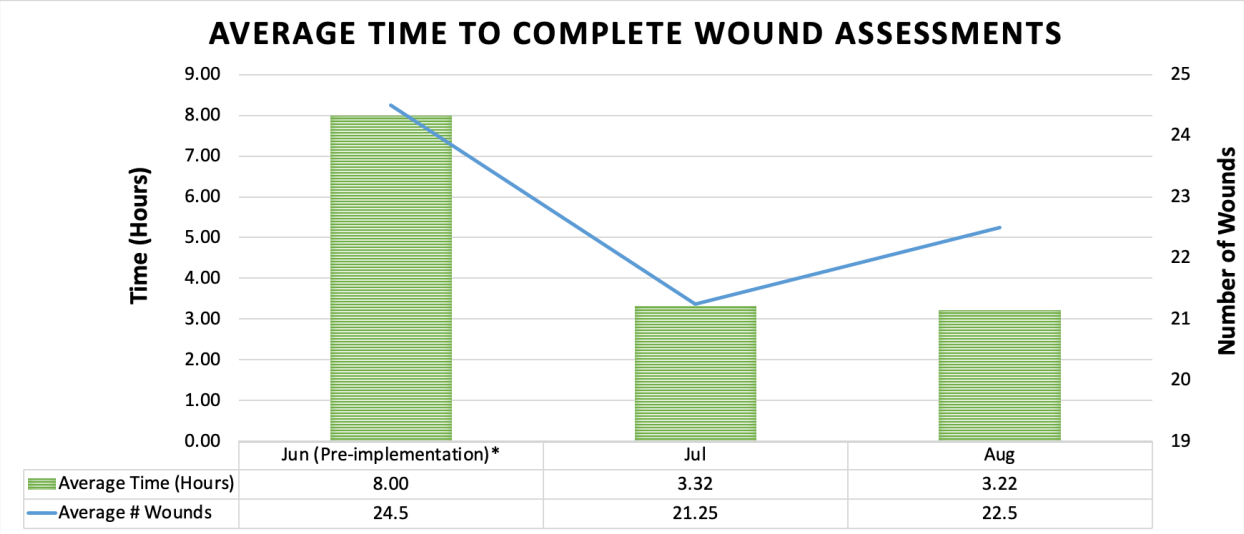
Table 3

Average Time to Complete Skin Rounds, Number of Patients, and Number of Wounds

Month	Average Time	Average # Patients	Average # Wounds
July	3.32	10.25	21.25
August	3.22	10.75	22.5

Figure 2

Average Time to Complete Wound Assessments – Pre and Post-implementation



Cost Benefit Analysis

With the implementation of 3D-wound technology, the skin rounds team was able to realign nursing staff needed on the team. The original skin rounds team consisted of 1 wound care nurse, 2 registered nursess, and 2 licensed vocational nurses. Because the 3D-wound technology automated some nursing duties, such as wound measurements and documentation, a different mix of nursing personnel could be used to comprise the skin rounds team. The post-implementation skin rounds team consisted of 1 wound care nurse, 1 registered nurse, 1 licensed vocational nurse, and 1 certified nurse assistant. Table 4 shows a breakdown of initial and annual costs pre- and post-implementation. Hourly wages were based on the facility's pay scales for each staff. With the change in nursing personnel used on skin rounds plus the decrease in time needed to complete skin rounds, there is a significant savings in cost. The initial return on investment was calculated to be $2.74 and annually thereafter was calculated to be $2.70.

Table 4

Cost Analysis

Cost Category	Unit cost	Pre-implemenation (prior to 3D-Wound Technology)				Implementation (with 3D-Wound Technology)			
		Number of Nursing Staff/Item	Number of Skin Rounds per Year	Time Per Skin Rounds	Cost per Year	Number of Nursing Staff/Item	Number of Skin Rounds per Year	Time Per Skin Rounds	Cost per Year
Personnel									
Wound Nurse (RN)	[a]$60/hr	1	52	8 hrs	$24,960.00	1	52	3.27 hrs	$10,202.40
RN	[b]$60.00/hr	2	52	8 hrs	$49,920.00	1	52	3.27 hrs	$10,202.40
LVN	[b]$31.22/hr	2	52	8 hrs	$25,975.04	1	52	3.27 hrs	$5,308.65
NA	[a]$26.43/hr	0	0	0	$0.00	1	52	3.27 hrs	$4,494.16
Supplies									
iPad	[d]$400	2	n/a	n/a	$800.00	0	n/a	n/a	n/a
Camera sensor with bracket	[d]$400	2	n/a	n/a	$800.00	0	n/a	n/a	n/a
Software subscription	$5,700.00	2	n/a	n/a	$11,400.00	2	n/a	n/a	$11,400.00
Training Supplies	[d]$100	1	n/a	n/a	$100.00	n/a	n/a	n/a	n/a
			Grand total Initially		$ 113,955.04			**Grand Total**	$ 41,607.61
			Grand total Annualy		$ 112,255.04				

Note: All mean hourly wages are for the San Diego Facility.

[a]Mean hourly wage from the Office of the Chief Human Capital Officer (OCHCO) Title 38 Pay Schedule (2022)

[b]Mean hourly wage from Office of the Chief Human Capital Officer (OCHCO) LVN Pay Scale (2022)

[c]Mean hourly wage from Office of the Chief Human Capital Officer (OCHCO) NA Special Salary Rates (2022)

[d]One time purchase

Conclusion

Implementation of 3D-wound technology increased efficiency of wound assessments by the skin rounds team. By creating a more efficient and streamlined process for wound assessments the number of manhours needed on skin rounds decreased, which allowed more time for nurses to tend to other nursing related and patient care responsibilities. By facility wide roll out of 3D-wound technology, a standardized wound assessment process can be used throughout the facility both inpatient and outpatient. Future studies can be done to demonstrate how the accurate wound measurement data obtained with the 3D-wound technology influences treatment decisions that can lead to decreased lengths of stay.

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