AD-A252 600

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ted to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, viewing the collection of information. Send comments regarding this burden estimate or any other aspect of this urden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson ffice of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY	RT DATE 1992	3. REPORT TYPE AND DATES COVERED THESIS ~~XXXXXXXXXX~~

4. TITLE AND SUBTITLE
Wound Volume Measurement

5. FUNDING NUMBERS

1

6. AUTHOR(S)
Stephen J. Mazer, Captain

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AFIT Student Attending: St. Louis University

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/CI/CIA-92-032

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFIT/CI
Wright-Patterson AFB OH 45433-6583

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release IAW 190-1
Distributed Unlimited
ERNEST A. HAYGOOD, Captain, USAF
Executive Officer

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

92-17926

92 7 0 109

14. SUBJECT TERMS

15. NUMBER OF PAGES
36

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

WOUND VOLUME MEASUREMENT

Stephen J. Mazer, R.N., B.S.N.

A Digest Presented to the Faculty of the Graduate
School of Saint Louis University in Partial
Fulfillment of the Requirements for the
Degree of Master of Science in Nursing
(Research)

1992

Digest

A standardized and clinically available method to estimate wound volume is needed to determine rate of pressure ulcer healing. This quasi-experimental study was conducted to compare two methods (Jeltrate[R] mold and Kundin Scale) with a standardized, but relatively inaccessible method (planimetry).

Twenty-five Stage III and IV pressure ulcers (among 16 patients) were measured. The Jeltrate[R] method consisted of packing an alginate compound into the wound. Within two to five minutes the compound hardened and was easily extracted from the wound. Volume was calculated by weighing the mold and dividing by Jeltrate[R]'s density.

The Kundin Scale is a ruler-like device that measured length, width, and depth at the extreme wound margins. Volume was calculated by applying these measures to a formula specific to this scale.

Planimetry, the generally accepted standard method, calculated wound volume from a tracing made on a clear sheet of acetate and measurements of the wound's depth made with a cotton tipped applicator, and applying these measures to the formula of a geometric cone. Each measurement procedure was repeated by a co-investigator to assess for inter-rater reliability.

Data were analyzed using a paired t-test and

Pearson's correlation method. Costs of the different methods used in the wound measurement and the time required to complete each method revealed no clinical differences between the Jeltrate® and Kundin Scale methods.

These results support the economical use of either Jeltrate®, or the Kundin Scale method to serially monitor wound volume and, thus, wound healing over time. Planimetry is not a clinically feasible method because of its high expense and relative inaccessibility.

WOUND VOLUME MEASUREMENT

Stephen J. Mazer, R.N., B.S.N.

A Thesis Presented to the Faculty of the Graduate
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1992

COMMITTEE IN CHARGE OF CANDIDACY:

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Clinical Instructor Laurel Wiersema

Dedication

To my beloved grandfather, Stephen R. Mazer, Sr.

Acknowledgements

The author wishes to acknowledge the following: My wife Mary and two children for their love, patience and understanding for the many hours spent away at school studying; Richard Eaves, for his moral support and attentive ear; Dr. Norma Metheny, chairperson and advisor, for her advice, guidance, and assistance with the writing for this thesis; Dr. Barry Katz for his contribution and assistance with the statistical analyses for this study; Laurel Wiersema, M.S.N. for her clinical assistance, enthusiasm, and ever positive attitude during the course of this investigation; and the United States Air Force for making this all possible.

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Chapter 1

Background

Introduction

Skin, the largest organ of the body, covers 3000 square inches, and receives approximately one-third of the circulating blood volume (Jacob, Francone, & Losson, 1982). It's major functions include protection, sensation, thermoregulation, and metabolic functions. A wound is an interruption in the continuity of body tissue (Wysocki, 1989). Loughry (1991) defines a wound as a disruption of anatomic integrity of any tissue. Wounds can be classified in many different ways as to anatomical site, depth of wound, layers of tissue damaged, or etiology. From a treatment standpoint, they are classified as: (a) those without tissue loss (such as surgical incisions), and (b) those with tissue loss (such as venous stasis ulcers or those due to pressure, as in Stage II, III and IV decubitus ulcers). Wounds can also be classified by etiology as (a) surgical, (b) traumatic (such as mechanical or thermal injuries), and (3) chronic (as vascular insufficiency, pressure or diabetic ulcers). Rudolph and Noe (1983) defined chronic wounds as those wounds in which simple medical or surgical treatment does not produce easy resolution. Others agree with this definition (Kloth, McCulloch, &

Feedar, 1990). Chronic wounds usually lack both dermal and epidermal layers of the skin, are often irregular in shape and depth (due to many episodes of contraction and epithelialization), frequently occur over bony prominences, and/or on contoured areas of the body (Thomas & Wysocki, 1990). These characteristics make it difficult to objectively quantify accurate measurements. However, such measurements are important to determine a wound's rate and quality of healing (Thomas & Wysocki, 1990).

Nurses are in a better position to affect wound healing than are other health care providers. Since wound healing occurs over a period of time, and nurses share more time with the patient, their influence can greatly affect the success of healing. Wound care can be considered the nurse's domain (Cooper, 1990b).

Ambroise Pare', a French surgeon, stated, "I make the wound and God heals it" (Westaby, 1986, p. 4). This adage holds true to some extent today. Millions of dollars and man hours have been spent in understanding and enhancing wound healing. No single drug, or method of treatment has yet been found that accelerates normal healing. No one can improve on normal wound healing, the best that can be done is to prevent or remove all factors which interfere with this process (Brody, 1985). Messer (1989) also feels that many wounds left alone heal by themselves without any interventions. Nevertheless, if factors affecting wound healing could be better understood, clinicians could use interventions that would optimize healing. A number of factors can interfere with wound healing. Among the more common hindrances to wound healing are infection, malnutrition, hypovolemia, and hypoxemia (Wysocki, 1989.)

Part of a nurses's responsibility is to assess a patient's wound and document response to therapeutic interventions. Three methods which can be used to assess wound healing include histologic sections, tensile strength, and area measurements (Thomas & Wysocki, 1990). The first two methods are beyond the scope and practice of nursing, but the latter, area measurements, are within the realm of nursing practice.

One aspect of wound assessment is measuring wound size. While there are many different techniques to measure a wound, there is not one standardized method. A standardized method of measurement is important to determine the amount of healing that has occurred in response to various treatments, medications, and disease processes. The ability to accurately measure wound volume allows the nurse to establish goals for wound healing to assess attainment of that goal. There are two basic categories of wound measurement, these include wound surface area, and wound volume. Simply stated, wound surface area measurements can be described as length by width measurements, and wound volume as three dimensional measurements, length by width by depth.

Conceptual Framework

The conceptual framework used for this study was adapted from a variety of authors to support a model for wound healing (Flynn & Rovee, 1982; Sieggreen, 1987; Taylor-Lake, 1983; Wysocki, 1989).

Wound Healing Model

Wound healing is usually subdivided into three categories called the inflammatory, proliferative, and maturation phase (Wysocki, 1989). This categorization, however, does not necessarily mean that these stages occur in a step wise and sequential manner. This process is more likened to a cascade of events sometimes overlapping and occurring simultaneously which results in the restoration of the continuity of the injured tissue. According to Wysocki (1989), the two main events that occur during this first phase are hemostasis (restriction of blood flow to the injured area and release of chemical factors to retard bleeding), and phagocytosis, (destruction of bacteria and removal of wound debris). The next phase is called the proliferative or regenerative phase and is characterized by the increased growth in epithelial cells. Epithelial cells make up the top layer of skin tissue cells. These epithelial cells move from around a wound's edges toward the center to promote filling. While epithelial cells form the surface layer of skin, it is the dermal, or middle layer of cells that give skin it's structural integrity (Flynn & Rovee, 1982). Collagen, the main component of dermal cells, forms the glue that binds the wound edges together (Taylor-Lake, 1983). At first collagen is laid down in a crisscross bridge-like pattern which acts to hold the wound together. At this point the wound is structurally weak and fragile. Neovascularization, another event in the second phase, is the formation of tiny new blood vessels which supply the multiplying and growing new tissue with oxygen and nutrients (Wysocki, 1989). Another type of cell, a myofibroblast, is found in the wound and is believed to aid in wound healing. Myofibroblasts have contractile properties; by forming a bond with skin cells as they contract, they pull the wound edges inward (Sieggreen, 1987). In the last phase, maturation, the collagen fibers which were laid down in a disorganized fashion are broken and realigned, or remodeled in a parallel manner which increases the strength of this new tissue (Sieggreen, 1987). As the number of collagen fibers are increased, the strength of the new tissue increases. This entire process can occur in as little as three weeks or up to two years.

The wound healing model relates to the present study which attempts to identify a method that is most useful in a clinical setting to assess wound healing by determining wound volume. This is important because it is nearly impossible in a clinical situation to look at the microscopic activity of a wound to see if those cellular events are occurring which would indicate wound healing. By identifying an accurate method to measure wound volume, it wound be possible to compare measurements over time to indirectly indicate wound healing. In most cases as a wound heals it decreases in size by filling in missing tissue and by contraction of the wound edges.

Literature Review

The literature reviewed here is presented in a methodological fashion starting with simple methods used to measure wound surface area followed by more technologically advanced studies. Next, are studies describing wound volume, again starting with the more simple, and advancing to more involved studies of volume measurements using dental impression materials and foam elastomers.

Few published studies have described techniques to determine wound volume. Bohannon and Pfaller (1983) examined three methods in terms of their accuracy and practicality in measuring the area of pressure sores. The three methods were graph paper counting, weighing, and planimeter techniques. All involved tracing the perimeter of the wound. The graph paper counting method involved tracing the wound on metric graph paper and counting the number of square millimeters within the tracing. The second method, weighing, involved taking a tracing of the wound made on a transparency, cutting it out, weighing it, and then calculating the traced area of the cut out. The last method involved using a planimeter to trace the wound perimeter which produced a digital readout of the area. As a comparison they also used each method to determine the area of a known shape. They found that all three methods were accurate in determining these known areas, but there was a significant difference when used to compare two different clinician's tracings of the same wound. They suggest that the greatest source of error was not which method was used to determine the area, but the variability in how the two different clinicians traced the same wound. They limited their study to wounds which were less the one centimeter deep which more accurately describes a wound's surface area rather than it's volume.

Another study by Bulstrode, Goode, and Scott (1986) compared wound tracings, simple photography, and stereophotogrammetry with each other. They found that stereophotogrammetry was ten times more accurate in determining area compared to direct wound tracing and simple photography. Their methods of wound measurement are not practical for nurses in the hospital setting due to the cost and relative unavailability of the equipment involved, and the time factor both in training to use the equipment and in doing the procedure itself.

Kundin (1985) developed a tool that can be used to measure both wound surface area and volume. Her goal was to design an instrument that could measure irregularly shaped wounds while not endangering or distressing the person being measured. Another goal was to develop a tool that was simple and basic, and that could be used with simple mathematical formulas to give accurate estimates of area and volume. The tool, the Kundin Wound Gauge©, was developed in the shape of a Cartesian coordinate system and can be placed on top of a wound to measure wound surface area, or into a wound to measure volume. It is an inexpensive plastic coated, paper instrument designed to be thrown away after one time use to minimize the risk of infection to the patient or nurse. To compensate for the irregular shapes of decubiti or pressure ulcers, values from the Kundin Wound Gauge[c] are applied to mathematical formulas. For wound surface area the formula involves an ellipse, and for wound volume, it involves an elliptical paraboloid. No statistical data regarding validity of the Kundin Wound Gauge[c] have been published.

Thomas and Wysocki (1990) studied three different methods to measure wound surface area; these included planimetry, the Kundin Scale, and photography. They wanted to compare the three methods for their reliability and accuracy in measuring wound area. The sample consisted of 73 patients who had either decubitus ulcers or venous stasis ulcers. Each patient's wound was measured with each of the three methods. First, the wound was photographed and the image was traced with a digitizing tablet that calculated the wound's area. Next, an acetate tracing was made and an image analysis system (similar to that used with the photograph) was used to calculate the area. Lastly, the Kundin Scale was used. The latter method measures the wound in three dimensions (length, width, and depth) and then the area of the wound is calculated by using the measurements in a mathematical formula. According to Thomas and Wysocki (1990), all three methods were useful in measuring wound area; however, differences existed between them. The Kundin Scale tended to underestimate larger and irregularly shaped wounds when compared to planimetry and photography, but was more similar to them when smaller and more elliptical shaped wounds were measured. The acetate tracing and photograph images had the highest correlation without regard to wound shape. The authors concluded that method selection is dependent on the purpose of the measurement and other factors as equipment cost, accuracy desired, and the need for keeping a permanent record of the wound's area.

In an attempt to measure wound volume in eight healthy young adults with pilonidal sinuses, a group of researchers used an alginate hydrocolloid substance to make an impression of the wound (Pories et al., 1966). This alginate hydrocolloid (Jeltrate®), used by dentists, is a rapidly setting plastic, well tolerated by wounds and granulating tissues. The authors reported that the compound did not cause discomfort to the patients and reproduced the irregularities of wounds. The study's purpose was to examine the healing rates of these wounds at different times by using Jeltrate® impressions to measure the wound's size. Mold impressions were taken every three to four days until healing had progressed to the point that the volumes could not be measured with accuracy. Volumetric measurements were obtained by placing the mold in a graduated cylinder filled with water and measuring the volume of water displaced. Permanent casts of the molds were made using dental stone to save them for further study.

Another group of researchers also used Jeltrate® to measure wound volume (Resch et al., 1988). They used Jeltrate® to make a mold, or casting, of pressure sores in two subjects. Jeltrate®, in powder form, when mixed with water forms a type of putty which was placed into the wound. Because it is a relatively fluid material, Jeltrate® made an impression of the wound which included undermined areas. Once set, the material was still flexible enough to be easily extracted. The authors rinsed the mold, weighed it, and converted the measures to determine wound volumes. Resch et al. (1988) had experimented with several other dental compounds, but found Jeltrate® the most suitable material. They found that the Jeltrate® technique was easily performed at the bedside and required no special skills. They reported that this method is also quick, painless, and is not damaging to tissues.

Kloth et al. (1990) discussed different methods of objectively documenting wound size. A simple technique to measure wound volume was described for use on wounds that were gravity dependent (perpendicular to the line of gravity). Water from a syringe was injected into the wound cavity until it was filled. The water left in the syringe was subtracted from the starting amount which indicated the volume in cubic centimeters that was necessary to fill the wound.

Covington, Griffin, Mendius, Tooms, and Clifft (1989) described a method they used to measure a pressure ulcer, located over the ischium on a patient with quadraplegia, using an elastomeric dental impression material composed of vinyl polysiloxane, trade name Reprosil®. Their methodology differed compared to Resch et al. (1988) in that they took the negative impression of the wound, the mold, and made an exact replica of the wound by making a cast around it. To determine volume they filled the exact replica, or mold, of the wound with colored water. They found Reprosil® to be an acceptable material for this purpose of determining wound volume. Reprosil® also had minimal risks to the patient associated with its use.

Several research teams in England and Canada described methods to measure different types of surgical wounds using silastic foam, a synthetic silicone-based polymer (Gledhill & Waterfall, 1983), and a silicone foam elastomer sponge (Macfie & McMahon, 1980; Wood & Hughes, 1975; Wood, Williams, & Hughes, 1977). The silicone foam elastomer sponge is an unpolymerized elastomer, when mixed with a catalyst expands to four times its original volume, and sets into a soft, pliable foam stent. The authors described its use both as a comfortable dressing for wounds, and also as a means to measure wound volume. Volume was calculated with the stent using the water displacement method.

Discussed in this section were methods from the two general categories of determining wound healing, wound surface area and volume measurements. These general categories were included because they are the most often used, and most practical for use in the clinical setting, compared to histologic sections and tensile strength measurements. There has been recognition that wound surface area measurements are not adequate to describe wounds which are more than a few centimeters in depth, and methods to measure wound volume are either not very accurate, or have not been studied using more than a few subjects. Also, some of the methods developed involve highly technological pieces of equipment as stereophotogrammetry and digitizing tablets with computer imaging analysis.

These are not practical for general clinical use due to the availability and cost of the equipment involved, and the time it takes to complete the measurement procedure. The Kundin Scale as the research pointed out is a simple and inexpensive tool, but it is only good as an index of wound size (Thomas & Wysocki, 1990). Perhaps, a more accurate method which is still relatively easy and inexpensive exists. This study examined these questions.

Statement of the Problem

In clinical practice there is not a standardized accurate wound volume measurement method which takes into consideration wound characteristics such as undermining, irregular shape and depth, and occurrence on contoured areas of the body. While methods exist for measuring wound volume, they are often inaccurate, time consuming, or expensive. For a method to be practical for nurses, it must: (a) be accurate enough to justify the nurse's time to do the procedure (measuring), (b) involve a minimum amount of time, and (c) involve equipment that the nurse may obtain easily and inexpensively.

Statement of Purpose

The purpose of this study was to identify the more accurate and clinically useful method (Kundin Scale or Jeltrate[R] mold) for measuring wound volume when compared to a standard (planimetry).

Research Hypotheses

1. The impression, or Jeltrate[R] mold-making method of determining wound volume will more accurately measure the true volume of a wound than will the Kundin Scale when compared to a standard using planimetry.

2. The impression, or Jeltrate[R] mold-making method of determining wound volume will not require significantly greater time or effort on the part of nurses than will the Kundin Scale method.

3. The impression, or Jeltrate[R] mold-making method of determining wound volume will not cost significantly more than the Kundin Scale method.

Chapter 2

Methodology

Overview of Research Approach

A quasi-experimental study was conducted which compared two methods used to determine wound volume (the Kundin Scale and the Jeltrate[R] mold method) with a standardized method (planimetry). Twenty-five Stage III and IV pressure ulcers (among 16 subjects) were measured. Methods were: (a) the Kundin Scale, a ruler like paper device which measured a wound at the extreme points (length, width, and depth), (b) Jeltrate[R] mold method which consisted of packing Jeltrate[R] (a putty-like material) into a wound, and removal within two to five minutes of a hardened mold that conformed to the shape of the wound, (c) and planimetry which involved making a tracing of a wound on acetate film and obtaining depth measurements with sterile swabs. Each measurement procedure was repeated by a co-investigator to assess for inter-rater reliability. Costs of the different methods used in the wound measurements and the time required to complete each method were also compared to determine their usefulness and practicality for wound measurements at the bedside.

Operational Definitions

The following terms were defined for the purpose of this research study:

<ins>Acetate</ins>. A thin, transparent film used to make a tracing of a wound's outline for the planimetry method.

<ins>Jeltrate</ins>[R]. An alginate compound used in making dental impressions (manufactured by the L.D. Caulk Co., Division of Dentsply International Inc., Milford, Delaware).

<ins>Kundin Wound Gauge</ins>[c]. A three dimensional, disposable, plasticized paper measuring device for use with wounds based on a Cartesian coordinate system (manufactured by Pacific Technologies and Development Corp., San Mateo, California).

<ins>Planimetry</ins>. A method to calculate wound volume from an acetate tracing using a computer, software, digitizing pad and pen.

<ins>Pressure Ulcer</ins>. Lesion produced from prolonged pressure on skin and deeper tissues from an external object.

<ins>Stage III Pressure Ulcer</ins>. Part of a four stage system used to classify wounds by depth. Ulceration extends through the skin layers into subcutaneous tissue.

<ins>Stage IV Pressure Ulcer</ins>. Part of a four stage system used to classify wounds by depth. Most severe stage, deepest underlying tissue involved extending into muscle and bone.

Sample and Setting

The research environment involved a large, midwestern, metropolitan Medical Center. Included were subjects from a variety of medical units and an outpatient wound clinic.

A convenience sample of 16 subjects (having a total of 25 pressure ulcers) was obtained between October 25, 1991 and February 13, 1992. Subjects were identified who met the inclusion criteria while making rounds with a Clinical Nurse Specialist, the co-investigator, and recruited for the study. Inclusion criteria included: (a) Stage III or Stage IV pressure ulcer, (b) age 18 years or greater, (c) non-infected ulcers as defined by Medical Record, (d) absence of sinus tracts, (e) 90% or greater granulation tissue, and (f) informed consents from patient (or significant other) and attending physician.

Data Collection

After informed consents were obtained, measurement procedures were scheduled during routine dressing changes to facilitate the staff nurse's time and the patient's convenience. The patient was positioned into a comfortable sitting, or lying position with the wound accessible to the investigators. The two investigators performed the measurement procedures independently, to prevent bias of measurements, and recorded their own data immediately after the measurements were obtained. A stop watch was used to record the time needed to complete each method to measure wound volume. The principal investigator traced the outline of the wound onto acetate paper and used sterile swabs to obtain a depth measurement. The principal investigator then inserted the Kundin Wound© Gauge into the wound and obtained length, width, and depth values. The co-investigator next repeated the same two measurement methods. The principal investigator mixed Jeltrate® powder with a standardized amount of lukewarm tap water (a standardized measuring vial was supplied with each box of Jeltrate®). The admixture was packed firmly into the wound with a tongue blade. After two to five minutes the Jeltrate® mold had hardened sufficiently to allow its easy removal from the wound in one piece. The mold was placed in a resealable plastic bag to prevent drying out until weighing could be performed on a gram scale. A gram scale was made available to the investigators to use in the hospital's pharmacy department. The co-investigator similarly repeated the Jeltrate® mold method. The wound was cleansed with sterile 0.9% Normal Saline and dressed according to the attending physician's prescription. The molds were weighed and volumes were calculated by dividing the Jeltrate® mold's weight by it's density. Results were in cubic centimeters. A mathematical formula specific to the Kundin Wound Gauge[c] was applied to the Kundin Scale values to obtain wound volumes. The acetate tracings were outlined on a digitizing pad (using a computer software program) and area measurements were displayed on the computer screen. Wound volume was calculated by applying these results to the formula of a geometric cone. All measurements were recorded on flow sheets and identified by investigator and wound number. The subject's names were not included in the data collection tool. Wound volumes were calculated as described and results were reported in aggregate for statistical analyses.

Chapter 3

Data Analyses

After termination of the data collection period, 25 Stage III and IV pressure ulcers had been measured by the two investigators using three different methods. Two different statistical methods were utilized for the analyses, paired t-test (to compare mean values) and Pearson's correlation coefficient. These were used for comparisons between raters for each of the measurement methods (within method comparisons), and for comparisons of the two methods against planimetry, the standard (between method comparisons). Inter-rater reliability for the measurement methods ranged between .95 to .99, $p < .001$ (Table 1).

Comparisons of the mean wound volumes between the two raters were found not to vary significantly at the $p=.05$ level (Table 2). Because the measurements were found to be reliable across raters, the averages of the two measurements by the raters were used in subsequent analysis (for between method comparisons).

Correlations between the three methods were strong, with the Kundin Scale and Jeltrate[R] methods being the most correlated ($r = .96$). There were somewhat lower correlations between planimetry and Kundin Scale methods, and planimetry and Jeltrate[R]

Table 1

<u>Correlation Between Two Raters</u>

Method	Correlation
planimetry	0.98***
Kundin Scale	0.95***
Jeltrate[R]	0.99***

*** ($p<.001$)

Table 2

Comparisons of Means Using Two Raters

Method	Rater				Paired t (df=24)
	principle		co-investigator		
	mean	SD	mean	SD	
planimetry	6.70	9.87	6.73	8.96	.08(ns)
Kundin Scale	7.57	10.77	6.60	8.54	1.27(ns)
Jeltrate[R]	10.02	12.73	9.58	11.49	1.05(ns)

ns (not significant at the .05 level)

methods (r =.93 and .90 respectively) at the $p < .01$ level (Table 3).

Comparisons of mean ratings between methods (Table 4) found no statistically significant difference between planimetry and Kundin Scale methods at the .05 level. Statistically significant differences among the means did exist between planimetry and Jeltrate®, and Kundin Scale and Jeltrate® methods at the .01 level. Table 4 also shows that the Jeltrate® method yielded larger volumes than did planimetry or Kundin Scale methods. In addition, differences among the means for the three methods were largest between Jeltrate® and planimetry (3.09 cubic centimeters), and Jeltrate® and Kundin Scale methods (2.72 cubic centimeters). Although these differences were statistically significant, they were not considered to be clinically significant.

Hypothesis Number 1 stated that the Jeltrate® method would more accurately measure wound volume than the Kundin Scale when compared to planimetry (the accepted standard method). However, because the Kundin Scale was more accurate than Jeltrate® when compared to planimetry, (no statistically significant difference between Kundin Scale and planimetry), Hypothesis Number 1 was not upheld.

Table 3

Correlation Among Three Methods

planimetry	Kundin Scale	Jeltrate®
1.00	.93**	.90**
	1.00	.96**
		1.00

** (p<.01)

Table 4

Comparison of Mean Ratings Between Methods

Method Comparison	Mean	SD	Paired t (df=24)
planimetry	6.71	9.37	.52 (ns)
Kundin Scale	7.08	9.53	
planimetry	6.71	9.37	2.78**
Jeltrate®	9.80	12.08	
Kundin Scale	7.08	9.53	3.47**
Jeltrate®	9.80	12.08	

ns (not significant at the .05 level)
** ($p < .01$)

Times required to complete each measurement method were also made. The Jeltrate[R] method required a greater amount of time (3.20 minutes) than either planimetry or the Kundin Scale (1.09 minutes and 0.76 minutes respectively). Although this difference was statistically significant, it was not considered to be clinically significant (Table 5). Therefore, Hypothesis Number 2 was upheld.

Cost analysis (based on cost per wound measurement) for each of the methods revealed all were relatively inexpensive (Table 6). However, the initial outlay for planimetry equipment (computer system, software, and digitizing pad) makes this method relatively inaccessible in most clinical settings. The Kundin Scale and Jeltrate[R] methods were relatively inexpensive and the slight differences in cost were not considered clinically significant, thus, Hypothesis Number 3 was upheld.

Table 5

<u>Time Comparison of Methods</u>

Method	Mean	SD	Paired t
planimetry	1.08	0.39	3.52**
Kundin Scale	0.76	0.27	
planimetry	1.09	0.39	-8.22***
Jeltrate®	3.09	1.10	
Kundin Scale	0.76	0.27	-8.27***
Jeltrate®	3.20	1.13	

** ($p < .01$)
*** ($p < .001$)

Table 6

Cost Comparisons of Materials

Method	Approximate Costs
planimetry:	
-computer system (standard)	variable
-software program (BioQuant® System IV)	variable
-digitizing pad (SummaSketch® II)	variable
-acetate film (American Looseleaf/Business Products)	$55 for 100 sheets ($0.50 per sheet)
-acetate marking pens (Manomark®)	$35 per dozen ($2.92 per pen)
Kundin Scale:	
-Kundin Wound Gauge[c]	$2 per gauge
Jeltrate®:	
-Jeltrate® powder	$168 for 144 pouches[a] ($1.17 per pouch)

[a]One pouch of Jeltrate® contains 21 grams, enough to make two molds for most wounds.

Chapter 4

Discussion

Summary

This study was conducted to identify the more accurate and clinically useful method (Kundin Scale or Jeltrate[R]) to measure wound volume when compared to a standard (planimetry). Significant findings of the study included:

1. Consistent values were obtained between both raters, regardless of the measurement method used (inter-rater reliability for each measurement method ranged between .95 and .99).

2. No statistically significant difference existed between planimetry and Kundin Scale methods, but statistically significant differences did exist between Jeltrate[R] and planimetry, and Jeltrate[R] and Kundin Scale methods. These differences however, were not considered to be clinically significant.

3. The Jeltrate[R] method required a greater amount of time than the other methods, but the greater time was not considered clinically significant.

4. Jeltrate[R] and the Kundin Scale methods were both relatively inexpensive to use for wound volume measurements (especially when compared to the cost of planimetry).

Implications

Although, the Kundin Scale was the more accurate method, the mean difference between planimetry and Jeltrate[R] was 3.09 cubic centimeters. This difference is not considered clinically significant because a wound measuring larger by only three cubic centimeters wound not be treated differently in a clinical setting. Because inter-rater reliability was high for measures from either the Kundin Scale or the Jeltrate[R] method, it is reasonable to assume that serial measurements performed using either of these two methods would reveal progression of wound healing status over time. That is by consistently using one particular method (Jeltrate[R] or Kundin Scale) to measure the wound as it heals over time, a relative difference or change in wound volume could be seen, thus indicating the progression of wound healing.

Either method is comfortable and safe for patients. The Jeltrate[R] method did not cause patient discomfort, and left no residue on the wound surface. In addition, the Jeltrate[R] mold was relatively easy to remove from wounds without breaking, and readily molded to uneven contours of the skin, thus facilitating wound volume assessment with a relative degree of accuracy between raters. The Jeltrate[R] mold enabled the investigators to indirectly visualize the wound shape more accurately than the Kundin Scale. This could be significant to ensure that these difficult to visualize wound areas were packed to prevent the formation of a sinus cavity during healing of the wound.

Because of a perceived possible difficulty in removing the Jeltrate[R] mold from wounds with small openings and a large underlying cavity, and wounds with sinus tracts, the present investigators chose to exclude these types of wounds. This is a limitation to the use of the Jeltrate[R] method. For these types of wounds, the Kundin Scale would likely be a safer method to assess wound healing.

Another possible limitation of the Jeltrate[R] method cited by Cooper (1990a) is the possibility of under or over estimating wound volume by failing to adequately flatten the outer surface of the mold in relation to the surrounding tissue. In other words, if the mold were allowed to rise above the skin surface, wound volume would be over estimated. This possibility is greater with contoured wound surfaces (such as the heel), than with flat surfaces. However, one could argue that a similar problem could occur with the Kundin Scale in attempting to determine at which point to read the ruler.

Limitations

A limitation to this study was the small number of wounds that were measured (25). The low sample size was due to time restrictions imposed on the study period and the actual number of patient's who met the inclusion criteria. Also limited in this study were the types of wounds measured. Only Stage III and Stage IV pressure ulcers were included. Another limitation involved the use of only two investigators to assess for inter-rater reliability. Both the investigators were familiar with wound management and had previous experience using these methods.

Recommendations

Recommendations for future studies include:

1. Replicating the study using a larger sample size.

2. Expanding the types of wounds to include venous stasis ulcers, diabetic ulcers, or other wounds healing by secondary intention.

3. Extending inter-rater reliability testing to staff nurses without special expertise in wound management.

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