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THE PRACTICE OF USE OF +WoundDesk MOBILE APPLICATION FOR EVALUATION OF EXPERIMENTAL WOUND REPAIR DYNAMICS

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A development of advanced technologies requires an implementation of modern mobile applications to solve healthcare issues. Planimetric studies of trauma defects enables to reliably evaluate the dynamics of reparative processes. The mobile application market does not have a wide range of planimetric software. The authors of this article reference information about their own user experience of +WoundDesk mobile application to evaluate the dynamics of repairing a wound in experimental conditions to compare it with traditional planimetry. The use of +WoundDesk mobile application simplifies estimations of tissue trauma parameters, eliminates a requirement to use an additional measuring device and speeds up data processing.

Keywords*: wounds, regeneration, +WoundDesk, mobile healthcare.*

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There is no doubt that treating wound is important given the constant rise of domestic, work and sport traumas, immuno-deficient conditions and comorbid pathology [1].

At this time, a significant number of soft tissue reparation dynamics evaluation methodologies had been developed, but the search for optimal ones, from the point of view of time duration and simplicity, still continues [6, 7]. One of the more prolific methods of evaluating the speed of soft tissue reparative processes is the determination in dynamics of the wound area (S), where historic planimetric methodologies, as well as highly precise digital methods, called the "golden standard", are applied [6, 7]. The current evaluation methods of reparation dynamics are very laborious, require special skills, and take too much time, which is impacts the practicing specialists [5, 7]. There is no

doubt that the determination of the volume of the trauma, not only its area, is more progressive [6, 7].

A rapid development of IT technologies over the last decade enabled new healthcare opportunities [2]. A domination of PC-based portable devices leads to a necessary development and implementation of modern evaluation methods of dynamics of wound reparations [3, 4]. The speed of measurements, simplified usage, detailed information and data storage ability is not the most complete list of requirements to which a contemporary mobile application should correspond to. In our opinion, the abovementioned requirements are met by +WoundDesk mobile application, which was jointly developed by the University of Geneva and Swiss Association of Tele-medicine and Electronic Healthcare [7].

The purpose of the study: to study possibilities of using +WoundDesk mobile application to evaluate dynamics of wound reparation in experimental conditions.

Materials and methods: The study was performed on 20 white rat males, divided into control and experimental groups, with 10 specimens in each group. Animals of each study group underwent a modeling of soft tissue wounds per original methodology with subsequent daily treatment per the standard scope.

Modeling of soft tissue wounds. A preliminary shaved area of the rat's neck skin was treated twice with 0.05% aqueous solution of chlorhexidine bi-gluconate and washed away with a physiological solution. Along the template, a scalpel was used to dissect skin and subcutaneous tissue along with the surface fascia in the shape of an ellipse with a diameter ≈ 1.0 cm. A dissection of the scab and necrotized tissues in the area of healthy tissues, with subsequent covering of the wound with a sterile gauze and affixing it to the surrounding skin with a waterproof film bandage.

An evaluation of dynamics of the wound surface area in the control group was performed daily per traditional methodology, while the experimental group was evaluated by the +WoundDesk smartphone application.

Traditional planimetric research methodology. L. N. Popova's methodology (1942) was used as a standard to evaluate the wound reparation dynamics. Wound contours, impressed on a transparent film, were transferred to a plotting paper and wound area was calculated in square millimeters. A percent of wound reduction over 24 hours was calculated by the following formula:

S% = (S − Sn) / (S x t) x 100%, *(1)*

where S is an area of the wound at a previous measurement;
Sn is an area of the wound at a current measurement; t is the time between 24 hour measurements.

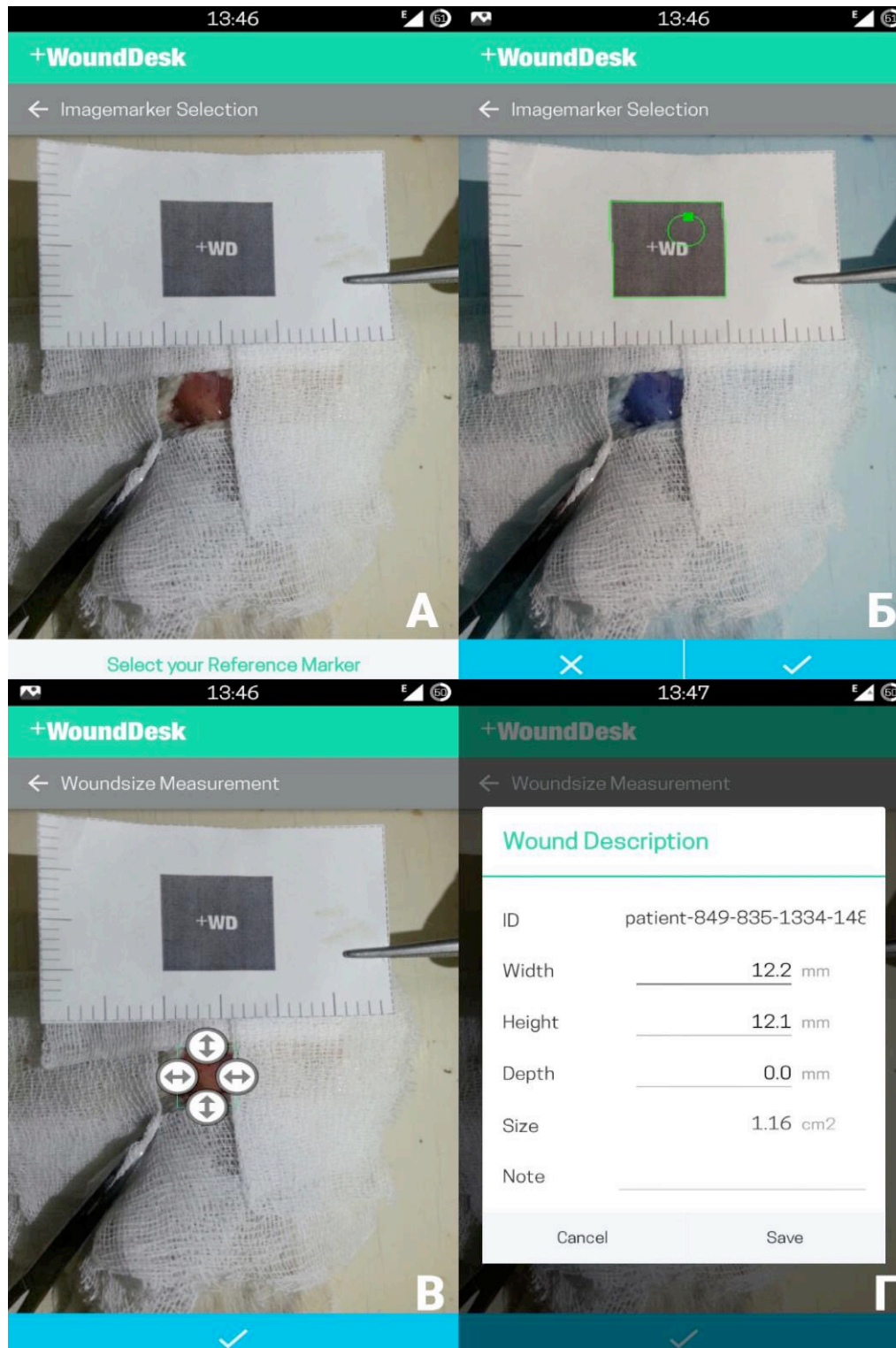*A measurement of the wound surface area using +WoundDesk mobile application.*

Figure 1. Procedural steps with +WoundDesk mobile application:

A)   +WD Marker placement parallel to the researched wound borders.
B)   +WD Marker detection
C)   Determination of borders of the researched wound borders using a thumb knob
D)   Measurement results

The application is based on using an Android operating system smartphone camera. Operating the application requires a registration on the manufacturer's official website, where a personal account is created, and the registration is accessible by the whole organization, as well as there is +WD indicating scale (provided by the application developers after registration), which compare contours of a studied wound. The updated application has a capability to exchange data between specialists by using the Internet, which, in turn, reduces data processing time for workers.

To start working with the application, it is required to sign in into the account. A patient's profile is completed, where it is required to indicate the location and how the trauma happened (one of several options is offered). Based on the completed profile of the dynamic monitoring process, one of standard treatment options is offered.

To obtain photos, Takeanewphoto mode is selected in the application, which turns on the mobile application photo camera. +WD indicator (Figure 1A) should be placed next to the studied wound.

The wound area is photographed, and the program recognizes +WD marker (Figure 1B) thereafter and requires a manual detection of wound borders using a thumb knob (Figure 1C). Next, an automatic calculation of the wound surface area is performed and the result is provided (Figure 1D).

Results and their analysis. +WoundDesk mobile application determines the wound surface area by calculating the ellipse area:

$$S = 0.785 \ x \ h \ x \ L, \qquad (2)$$

where h is the height and L is the length [7]. It is important to note that the error of elliptical wounds is about 5%, and for rectangular wounds may reach 20 – 25% [6, 7]. Since specialist in practice often see wounds of irregular oval shape with uneven edges, it is important to evaluate the level of correlation of measurements made by the application with measurements made by the classical methodology by formula appropriate for small samples:

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{[\sum x^2 - \frac{(\sum x^2)}{n}][\sum y^2 - \frac{(\sum y^2)}{n}]}}, \qquad (3)$$

where x and y are measurement parameters of the wound surface area made by the mobile application and by the classical planimetry, respectively, and n is a number of measurements. Furthermore, r index is 0.921, which indicates a sufficient precision level of measuring the wound surface area by the mobile application. Also, an important role is

played by the amount of time spent to measure and process data using a traditional planimetry compared to the mobile application (Table 1).

Table 1. A comparative analysis of the time spent while evaluating the dynamics of reparation using traditional planimetry and +WoundDesk mobile application

Case No.	Time spent on collecting and processing data using traditional planimetric research, min	Time spent on collecting and processing data using the mobile application, min
1	3	0.8
2	3.4	0.5
3	2.8	0.5
4	3.2	1.2
5	2.9	0.7
6	3.5	0.8
7	3.5	1
8	3	0.5
9	2.7	0.8
10	3.2	0.5
Total time	31.2	7.3

It took 4 times less time for specialists to evaluate the dynamics of regeneration using the mobile application when compared to the traditional planimetry.

In order to work with non-oval (non-elliptical) shape wounds, it is proposed to introduce estimated empirical coefficients: for triangular shaped wounds k = 0.619, and for rectangular and square shaped wounds k = 1.273. The introduction of these coefficients enables more reliable results of measurements for various shapes of soft tissue wounds using +WoundDesk mobile application.

To level measurement errors using mobile applications, it makes sense to develop software, which can perform a differentiated calculation of the wound surface area depending on the geometric shape of the wound:

1) For non-elliptical shaped wounds, it is based on the method of rectangles:

$$\int_a^b f(x)dx \approx h \sum_{i=1}^{n} f\left(x_{i-1}+\frac{h}{2}\right) = h \sum_{i=1}^{n} f\left(x_i -\frac{h}{2}\right), \qquad (4)$$

where h is a mesh size.

2) For elliptical shaped wounds, it is based on the formula for the area of ellipse:

$S = 0.785 \ x \ h \ x \ L,$

where h is the height and L is the length.

As it was mentioned, an important part of evaluating the dynamics of regeneration is the measurement of the volume of a wound. The mobile application automatically measures the length and width of a wound. However, the depth of a wound must be performed manually, since the work is performed in 2D. Hence, it is not difficult to determine the volume of experimental elliptical wounds by the following formula:

$V = S \ x \ D,$

where, S is the wound area and D is the depth.

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Conclusion: Using +WoundDesk mobile application to evaluate the dynamics of the wound reparation corresponds to modern tendencies of implementing mobile healthcare technologies, which simplifies mathematical calculations of wound parameters, enabling a reduction in measuring time up to several seconds, eliminates the need for additional measuring and calculating devices, as well as eliminates a direct contact of a lab animal with devices, in comparison with traditional planimetric research methods.

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