

aranZmedical

How SilhouetteStar Works – Silhouette v3.13

Table of Contents

1	Introduction.....	3
2	Creating the Wound Model.....	3
2.1	Capturing the Data.....	3
2.2	Creating the Wound Model for a Convex Surface	4
2.3	Creating the Wound Model for a Concave Surface	4
3	Determining the Wound Dimensions.....	6
4	Summarizing Measurements.....	7
5	Frequently Asked Questions.....	9

1 Introduction

When SilhouetteStar is used to measure wounds, it captures a sequence of photographs that contain an image of the wound, with and without the three laser lines. From these images, there are two distinct stages to obtain the measurements. The first stage is creating a mathematical model of the wound, referred to as the “wound model”; this process is described in Section 2. The second stage is determining the wound dimensions from the wound model, and this process is summarized in Section 3. Note that wound model creation for concave wounds is slightly different for convex or flat wounds, and will be described separately.

2 Creating the Wound Model

2.1 Capturing the Data

During image capture, SilhouetteStar is held over a wound, as shown in Figure 1 (a), and a series of digital photographs are taken, some with and some without the laser lines. An image with the laser lines is displayed in the SilhouetteConnect software, as shown in Figure 1 (b).

The three laser lines can be extracted from the images and drawn in three-dimensional (3D) space, as illustrated in Figure 1 (c).

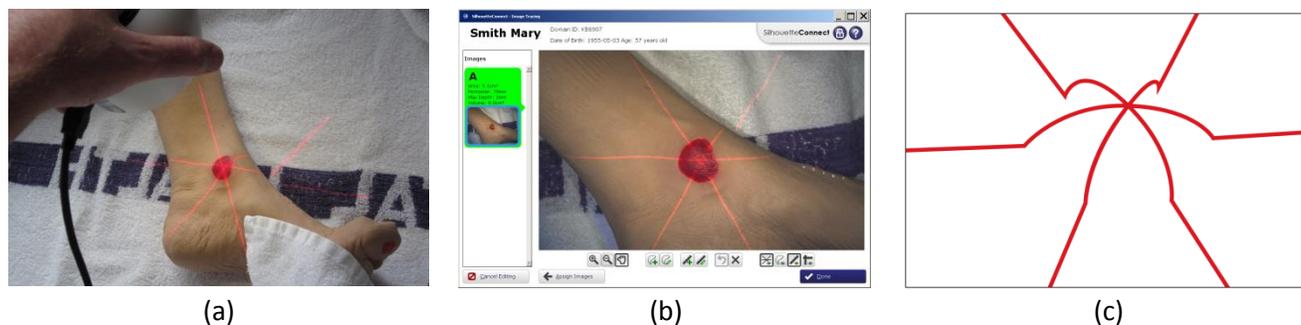


Figure 1: Capturing an image of a convex wound: (a) SilhouetteStar held over the wound; (b) the resulting image of the wound in SilhouetteConnect; (c) the laser lines drawn in three-dimensional space.

2.2 Creating the Wound Model for a Convex Surface

Figure 1 above shows SilhouetteStar collecting data from a convex wound. Using the 3D lines as shown in Figure 1 (c) as a 'scaffold', a 3D surface is stretched over the laser lines, as shown in Figure 2 (b). This 3D surface is our wound model – a computer generated representation of the actual wound.

During the data capture, the user has also drawn a closed curve around the wound boundary. This outline can be projected onto the wound model, as shown in Figure 2 (c).

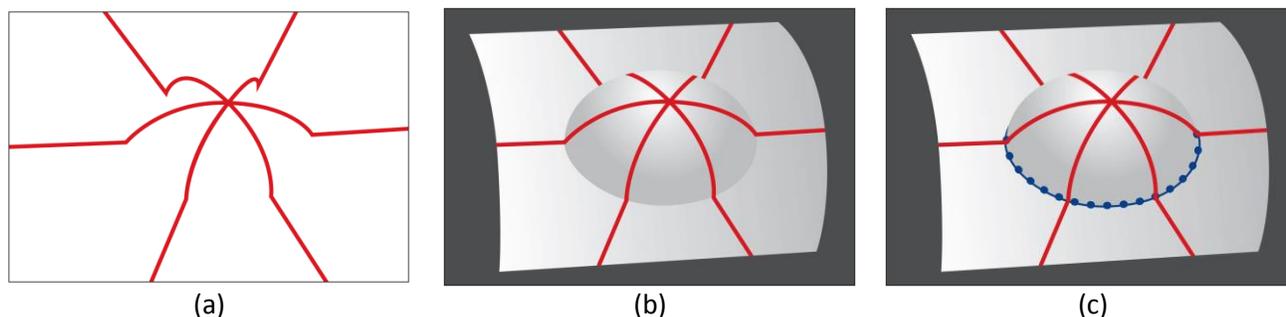


Figure 2: Creating a wound model of a convex surface: (a) the laser lines in three-dimensional space; (b) a surface is stretched over the three laser lines; (c) the user drawn outline (blue dotted line) is added to the wound model.

2.3 Creating the Wound Model for a Concave Surface

Figure 3 shows SilhouetteStar collecting data from a concave wound (a), how this appears in SilhouetteConnect (b), and the appearance of the laser lines in 3D space (c).

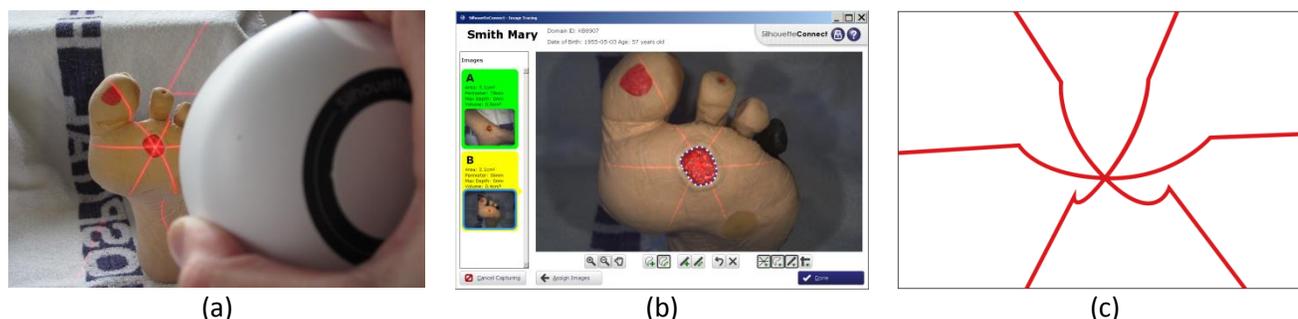


Figure 3: Capturing an image of a convex wound: (a) SilhouetteStar held over the wound; (b) the resulting image of the wound in the SilhouetteConnect software; (c) the laser lines drawn in three-dimensional space.

Using the 3D lines as a 'scaffold', a 3D surface is stretched over the laser lines, as shown in Figure 4 (a), onto which is added the user drawn outline, as shown in Figure 4 (b). Now if Silhouette detects that the wound model is representing a concave wound, it performs an additional step; it stretches a cap over the concavity, within the user drawn outline, as shown in Figure 4(c). The cap is used to provide a reference for depth and volume measurements, as explained in the next section.

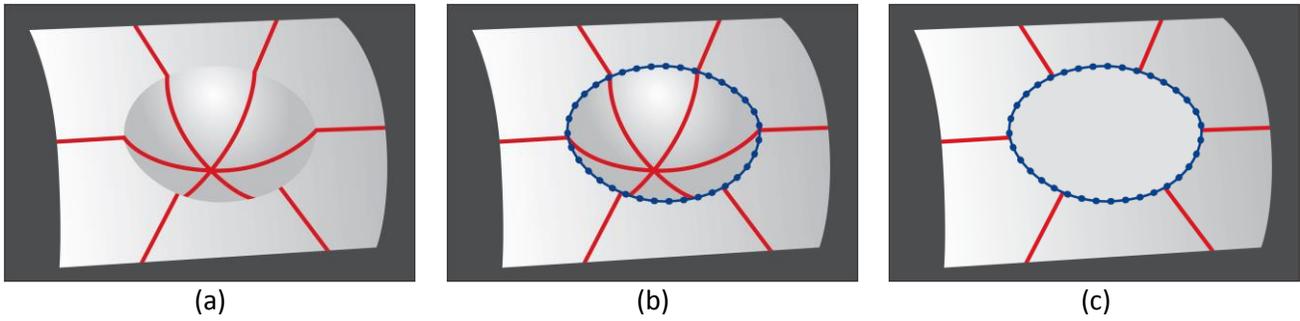
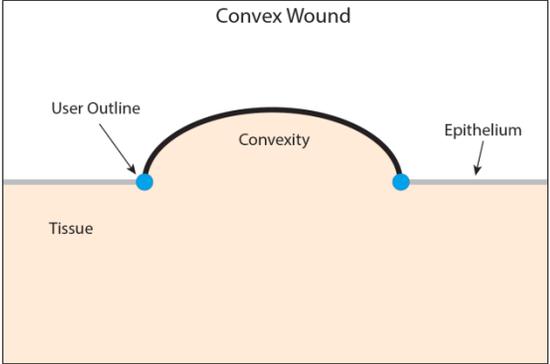
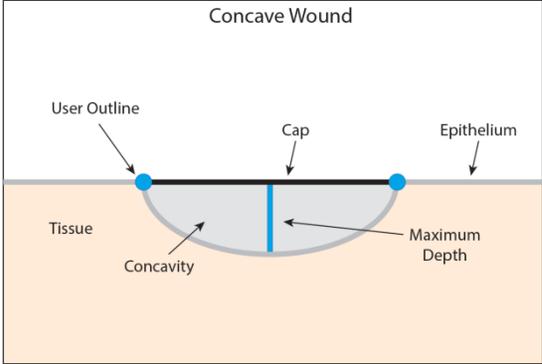
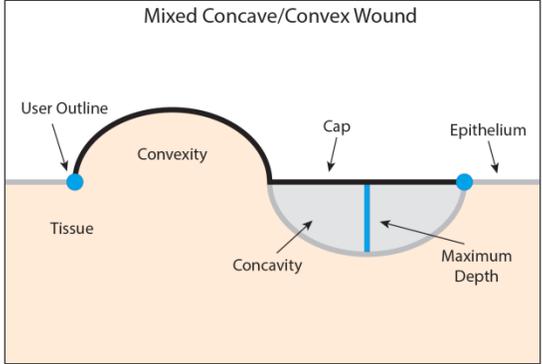


Figure 4: The wound model of a concave surface: (a) a surface is stretched over the three laser lines; (b) the user drawn outline (blue dotted line) is added to the wound model; (c) a cap is stretched across the user drawn outline and over the concavity.

3 Determining the Wound Dimensions

Silhouette calculates various wound dimensions, including area, perimeter, ruler(s), axes, maximum depth, mean depth and volume. The accuracy of the calculated dimensions will depend upon how well the wound model – which is simply a mathematical model of the wound – represents the 3D shape of the wound. This method has demonstrated high levels of accuracy and repeatability in a study based on 60 unique measurements made by three raters of four wound models. Inter-rater variability and intra-rater variability were both <1% for area and perimeter and <2% for average depth and volume.

Type	Convex Wound	Concave Wound	Mixed Concave/Convex Wound
Cut-away view			
Area	The area (indicated by the black line in the cut-away view) is the surface area of the wound model contained within the user drawn outline (blue dots).	The area (indicated by the black 'cap' in the cut-away view) is the surface area of the cap stretched over the concavity and contained within the user drawn outline (blue dots).	The area (indicated by the black line in the cut-away view) is the surface area of the wound model. The method used to calculate area is a hybrid of the convex and concave methods. Note that in general the cap is always on or above the wound.
Max depth	Not defined for convex wounds.	The maximum depth (indicated by the blue line) is the greatest distance from the cap down to the laser line on the wound bed, in a direction perpendicular to the plane of best fit through the user drawn outline.	
Mean depth	Not defined for convex wounds.	The mean depth is defined as the volume divided by the surface area.	
Volume	Not defined for convex wounds.	The volume is the region between the cap and the wound bed, represented by the grey shading.	
Perimeter	The perimeter is the length of the user drawn outline.		
Ruler	The ruler is used to define a distance between two user defined points. The magnitude is the length of an imaginary string laid onto the surface, and being held tight between the two end-points – following the convexities but skipping over any concavities ('tight string method').		
Axes	The wound's length and width is calculated according to a method determined by the user's organizational settings. For example, with the 'Longest Axis' method, the axes are oriented such that the length is the greatest linear dimension across the wound, and the width is the greatest linear dimension perpendicular to the length. The magnitude of the length and width is then calculated using the tight string method.		

4 Summarizing Measurements

When measurements are calculated they may appear in multiple places within the Silhouette user interface. In some cases measurements from individual images within a wound assessment will be summarized into a single measurement.

The following table outlines how Silhouette calculates the various values it displays at the image level and at the assessment level.

	Image Level	Assessment Level
Area	<p>The area associated with each outline on the image is summed to produce the total area.</p> <p>If the “ignore islands in area computations” organizational setting is enabled, outlines which are marked as islands are not included in the sum. If this setting is disabled, outlines which are marked as islands are subtracted from the sum.</p>	<p>Area is reported as the sum of all image level area measurements. If no image contains an area measurement a ‘-’ is displayed.</p>
Island Area	<p>The area associated with each outline marked as an island is summed to produce the total island area.</p>	<p>Island area is reported as the sum of all image level island area measurements. If no image contains an island area measurement a ‘-’ is displayed.</p>
Area Reduction	<p>Not applicable (not shown)</p>	<p>Area reduction is calculated as</p> $(1 - \text{area} / \text{baseline_area}) * 100$ <p>Where <i>area</i> is the area measurement for the current assessment and <i>baseline_area</i> is the area measurement for the user selected baseline assessment. If the user has not explicitly selected a baseline the baseline will default to the first wound assessment containing an area measurement.</p> <p>If the current assessment has no area measurement a ‘-’ is displayed.</p>

Perimeter	<p>The perimeter associated with each outline is summed to produce the total perimeter.</p> <p>If the “ignore islands in perimeter computations” organizational setting is enabled, outlines which are marked as islands are not included in the sum.</p>	Perimeter is reported as the sum of all image level perimeter measurements. If no image contains a perimeter measurement a ‘-’ is displayed.
Max Depth	<p>If there is only one outline then max depth is displayed.</p> <p>If there is one outline but a depth cannot be calculated (i.e. the outline does not contain the star-point and/or there are not sufficient detections) then max depth is not displayed.</p> <p>If there is more than one outline, or the image does not contain an outline max depth is not displayed.</p>	For max depth to be displayed there must be only one image within the assessment that contains an outline and that outline must contain the laser crossing point. If more than one, or no images, contain an outline a ‘-’ will be displayed.
Mean Depth	Same as max depth.	Same as max depth.
Volume	Same as max depth.	Same as max depth.
Axes (Width / Length)	All axes are displayed, ordered by the area ¹ of their associated outlines (largest to smallest). Axes are only reported for outlines, i.e. they are not shown for islands.	An axes width/length is only displayed if there is one outline (excluding any islands) across all images within the assessment. If there are no outlines, or more than one, a ‘-’ will be displayed.
Rulers	All rulers drawn on the image will be displayed, ordered by linear length (largest to smallest).	A length is only shown if there is a single ruler across all images within the assessment. If there are no rulers, or more than one, a ‘-’ will be displayed.

¹ For the purposes of ordering axes, the area of each outline is calculated as if the “ignore islands in area computations” organizational setting was enabled.

5 Frequently Asked Questions

Q: Why does Silhouette not display depths and volume if the star point is outside of the outline I have drawn?

- A. The accuracy of the wound dimensions depends upon how well the wound model represents the 3D shape of the physical wound. If the star point is not contained within the user drawn outline, the resulting model will not be able to meaningfully represent the wound sufficiently in order to calculate depth and volume. For example in Figure 5, there is only a single laser line through the wound bed. While area, perimeter, and linear dimensions will generally be able to be calculated with sufficient accuracy (and will be displayed), depth and volume are marked by a dash (-) in this situation.



Figure 5: While area and perimeter are calculated, there is no measurement for depth and volume if the star point is not contained within the wound outline.

Q: Why does Silhouette not display depths and volume for my wound containing two fragments?

- A. If two outlines are drawn on the one image, for example around two different fragments of the same wound, obviously the star point can only be inside one of the two fragments. In this situation the volume and depths are not displayed as Silhouette cannot meaningfully calculate the volume and depths of the fragment which does not contain the star point. For example in Figure 6, the star point is not in the left fragment. (Note that this also applies to a single outline containing an island.)

However, the area and perimeter of each fragment, as well as the total area and total perimeter of the fragments can still be determined. The total area and total perimeter are calculated as the sum of the area and sum of perimeter of the individual fragments respectively.

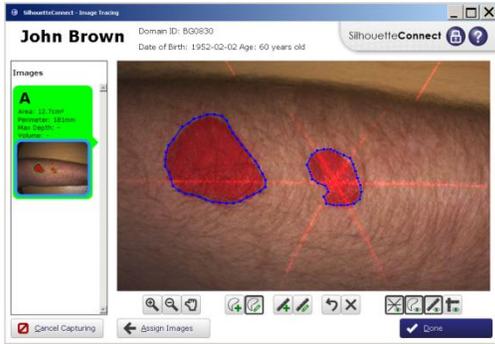


Figure 6: While area and perimeter are calculated, there is no measurement for volume and depth if there is more than one outline drawn on an image.

Q: How can Silhouette be used to calculate volume for a wound containing two fragments?

- A. It is possible to calculate the volume and depth of each fragment, if each fragment is captured in a separate image and each fragment has the star point within it. In this circumstance, while the volume and depth summary for the entire assessment will be reported as a dash (-), the measurements will be displayed for each fragment under the image, when the relevant image is selected in the SilhouetteConnect Dashboard.

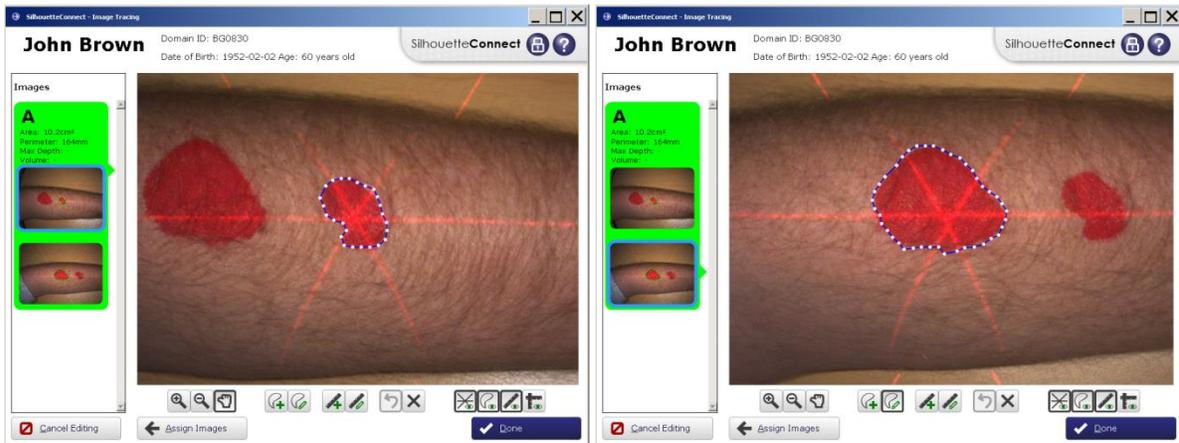


Figure 7: Volume and depth will be calculated for each fragment when there is only one outline associated with each image.