Design and implementation for wound measurement application

Li D

Abstract

Chronic wounds are difficult clinical problems that consume a large amount of resources including medical and nursing time as well as cleansing solutions, other topical applications, dressing products, bandages and elastic stockings. Thus, there is a need to develop an accurate and fully objective database application for wound measurement. A software interface written in the VB.NET languages for the measurement of wounds has been developed. The system uses an accurate measurement method capable of detecting small changes in an open wound surface area. This paper further describes the development of a relational database to measure the surface area of a wound, with the intention of improving the efficiency of wound measurement.

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Introduction

Chronic wounds are common problems in medical and nursing practice [1, 2]. Although chronic wound incidence and prevalence are largely unknown, chronic wounds, particularly relatively common ones such as leg ulcers, pressure ulcers and diabetic ulcers, have a considerable socio-economic impact in countries worldwide [1, 3]. Sound wound management has become one of the most crucial issues facing the health care system because of the exorbitant costs involved and the surge of the elderly population [2, 4].

Treatment practices vary widely from clinician to clinician and, subsequently, wound to wound and are frequently based on the underlying pathophysiological abnormalities [5, 6]. Currently, there are a variety of new pharmacologics and treatments available for managing wounds [6]. The evaluation of the efficacy of these new treatments has become a priority from both a research and clinical perspective.

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Wound measurement is often seen as an integral part of wound management. It is viewed as the objective evidence of a wound's healing progress compared with descriptive statements such as 'healing well' or 'wound satisfactory'.

Chronic wounds are irregular in shape and are difficult to measure; they are three-dimensional, possessing area and volume. Despite the wide range of available techniques to measure wounds, many of the methods commonly used are not entirely accurate and may not capture the full extent of the healing response. A reasonable approach to determining wound size during a brief patient encounter would be to document the wound's linear measurement – that is, perpendicular linear dimensions. Currently, most practitioners measure a wound as a rectangle or an ellipse. They calculate the area of an ellipse by measuring two perpendicular diameters, such as maximum diameter (major diameter) and maximum diameter perpendicular to the first diameter (minor diameter) [7]. Even though this method is simple and relatively cheap (for example, linear distance can be assessed with markings on a scalpel-handled ruler), the method is not precise because it assumes that the wound area can be calculated as a simple shape by measuring in two dimensions.

Change in the surface area of an open wound is seen as a useful measure of wound status [8]; it therefore is important to keep accurate visual records of these changes to determine the wound's status in the clinical setting [9]. The tools available for measuring the surface area of a wound are described as either invasive or non-invasive, depending on the level of intervention required by the technique to obtain the data [8].

Currently, there are several non-invasive techniques such as ultrasound, magnetic resonance or stereophotometry [10, 11]. More clinically accessible, however, are linear measurement and acetate tracing [8, 12]. Tracing involves using acetate paper or an occlusive dressing and maculating the area of the wound when traced by pen on to paper by conventional planimetric analysis [8]. However, planimetry has an inherent variability within the wounds measured [11, 13]. The method of planimetry has been challenged by more sophisticated techniques, such as computer assisted technology, video-image analysis and laser imaging processing [12-14]. Despite the wide range of available techniques, clinical methods that are both accurate for the researcher and minimally invasive and comfortable for the patient are lacking [8]. There is, therefore, a genuine need to develop an accurate, reliable and clinical acceptable technique to wound measurement.

Recently, a 12 month prospective randomised trial of the Alfred/Medseed wound imaging system (AMWIS) [15] was conducted at four sites in the Kimberley region of Western Australia [16]. Local clinicians were able to acquire sequential digital images of patients' chronic leg and foot ulcers for the duration of the patients' care. Wound management strategies were determined in consultation with wound care experts in Perth based on the images received. Similarly, healing rates were calculated remotely using the AMWIS.

Although the findings from the above mentioned study were significant, an important issue emerged, namely that the need for information technology (IT) support across all trial sites is critical to the programme being used successfully. It was noted that IT support was also critical during interruptions to network services that at times made it difficult to use the AMWIS system [16]. The research effort in our study is to try to develop a more user-friendly image database management application in order to advance the digital imaging, computerised recording and measurement technologies in chronic wound care practice.

Method

Program design

There are several factors to consider when assessing a wound – the wound classification by degree of tissue layer destruction or colour, the appearance of the wound bed and surrounding skin, and the shape and the size of the wound (specifically, length, width and depth) [17]. The length and width of many wounds are measured as linear distances from wound edge to wound edge and, for this, the consistent use of units of measure is essential.

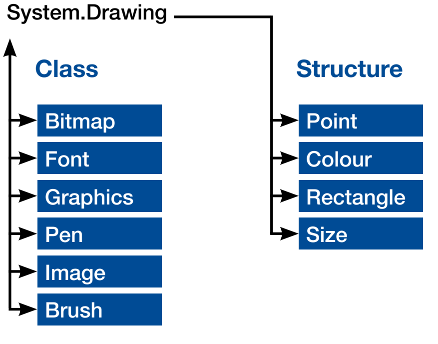
A user interface based on a personal computer was designed for the study. In order to address the complex requirements for wound measurement, the Microsoft Visual Basic.NET programming language was chosen as it includes a class library with more functionality than most other software packages [18]. The software interface developed with VB.NET will accept almost all popular image formats, as shown in the Table 1, which makes the system compatible with most of the digital cameras available on the market. In addition, with the help of Visual Basic.NET graphic contexts and graphic objects, the user-friendly interface can be further improved. Advanced graphics methods used in the system reside in the System.Drawing namespaces. Figure 1 illustrates a portion of the System.Drawing class hierarchy.

Table 1. Examples of supported image formats.

Examples of supported image formats

BMP	Windows bitmap image format
EMF	Enhanced Windows metafile image format
GIF	Graphics interchange format
JPEG	JPEG image format
PNG	Portable network graphics format
TIFF	Tag image file format
WMF	Windows metafile image format

Figure 1. System.Drawing classes and structures [18].



This study was designed to see how the proposed software might increase wound assessment accuracy and reliability. The parameters for software construction included that it was able to:

- Run under the current Microsoft Windows operating system.
- Follow a user friendly user interface.
- Precisely and objectively measure wound sizes by:
  - Calculating (by computer digitising method) the scanned image of wound tracing.
  - Calibrating the computerising measurement (using a ruler).
  - Calculating the distance on an image (using the mouse to indicate the two points).
  - Calculating the area on an image (using the mouse to indicate the outline (perimeter) of an image).
- Be efficient, by:
  - Enabling patient wound information to be easily stored and retrieved.
  - Storing data efficiently in a database using database tools such as Microsoft Access.
  - Establishing strategies for construction (coding standards and naming conventions).
  - Minimising error handling.
  - Improving image processing.
- Allow contrast.
- Ensure brightness.
- Detect an edge.
- Ensure availability by showing a:
  - Splash screen to keep the user informed during start up.
  - Menu system.
  - Toolbar.
  - Shortcut keys.
- Provide security by:
  - Showing a login screen (user is authenticated by entering the password).
  - Assigning a database password (creating users and groups).
  - Monitoring (Windows event log).
- Allow reporting by:
  - Viewing charts.
  - Allowing text to be printed or e-mailed.

Calculating the image area

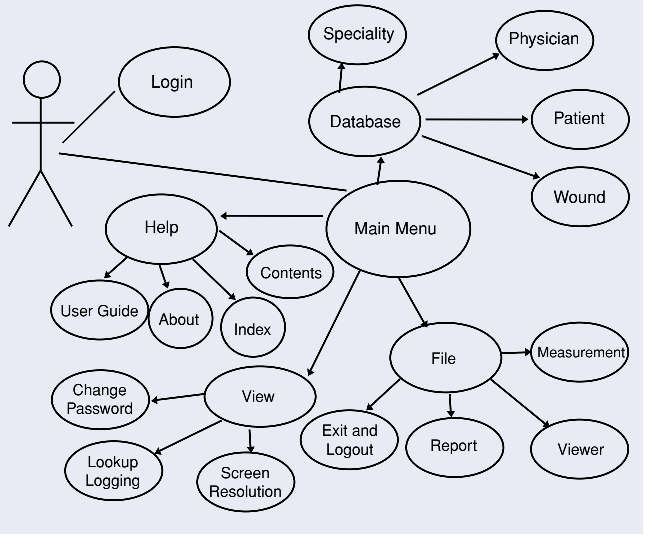
Figure 2 shows the use case (user view and communication) diagram for the wound measurement software. As can be seen, the user firstly interacts with the login screen and then with the main menu (if the user is identified to the system). The next step is to conduct the wound measurement. The wound image to be measured is imported from the database associated to the system. The wound size assessment should include length, width, area and perimeter.

To calculate the image area, the algorithm can be divided into five steps as shown in Figures 3.1-3.4:

- Digitise the outline (perimeter) of an image from right to left (←).
- Digitise the outline (perimeter) of an image from left to right (→).
- Digitise the outline (perimeter) of an image from top to bottom.
- Digitise the outline (perimeter) of an image from bottom to top.
- Calculate the area enclosed by that outline.

The lines of code (as shown in Table 2) demonstrate how to implement such an algorithm. This paper focuses on describing the interface and database design for this system. The algorithms used in calculating the wound size will be discussed in our future research papers.

Figure 2. Use case (user view and communication) diagram for the wound measurement software.



Figures 3.1-3.4. Calculating the image area.

Figure 3.1. Digitise the outline (perimeter) of an image from right to left (←).

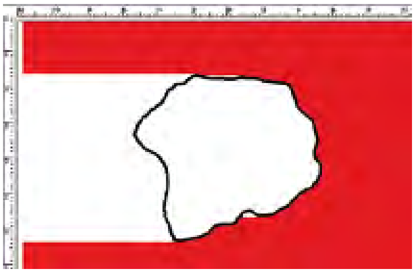


Figure 3.2. Digitise the outline (perimeter) of an image from left to right (→).

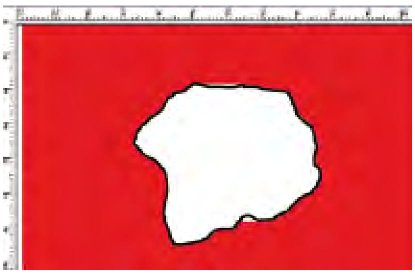


Figure 3.3. Digitise the outline (perimeter) of an image from top to bottom.

Figure 3.4. Digitise the outline (perimeter) of an image from bottom to top.

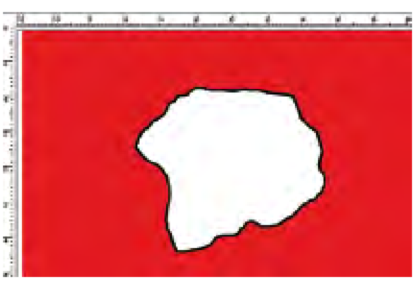


Table 2. Method to calculate area.

	Method to calculate area
1.	Private Sub CalculateArea (ByVal mode As Integer, ByVal color1 As
2.	Integer)
3.	On Error GoTo ErrArea
4.	Dim BitmapY, BitmapX, x, y, colorval As Integer
5.	Dim NewGraphic As Graphics = Me.PictureBox1. CreateGraphics
6.	‘Get dimensions of bitmap
7.	PictureBox1.Image = BitmapFromPicture
8.	BitmapY = BitmapFromPicture.Height - 1
9.	BitmapX = BitmapFromPicture.Width - 1
10.	‘Set cursor to wait cursor
11.	Cursor = System.Windows.Forms.Cursors.WaitCursor
12.	Call FillRightLeft(BitmapX, BitmapY, color1)
13.	Call FillLeftRight(BitmapX, BitmapY, color1)
14.	Call FillUpDown(BitmapX, BitmapY, color1)
15.	Call FillDownUp(BitmapX, BitmapY, color1)
16.	
17.	‘Display the results.
18.	PictureBox1.Image = BitmapFromPicture
19.	‘Set cursor to arrow cursor
20.	Cursor = System.Windows.Forms.Cursors.Arrow
21.	Dim counter As Long
22.	Dim area As Integer
23.	counter = 0
24.	‘count number of red pixels
25.	For y = 0 To BitmapY
26.	For x = 0 To BitmapX
27.	With BitmapFromPicture.GetPixel(x, y)
28.	If .R = 255 And .G = 0 And .B = 0 Then
29.	counter = counter + 1
30.	End If
31.	End With
32.	Next
33.	Next
34.	‘area percentage
35.	area = 100 - counter / BitmapY / BitmapX * 100
36.	‘display area in square centimeters
37.	txtArea.Text = CStr((BitmapY / NewGraphic.DpiY) * 2.54 _
38.	* (BitmapX / NewGraphic.DpiX) * 2.54) * area / 100
39.	ErrArea:
40.	MsgBox(“Unexpected error - GDI+. Try again”,
41.	MsgBoxStyle.Critical, “Error Message to User”)
42.	
43.	End Sub

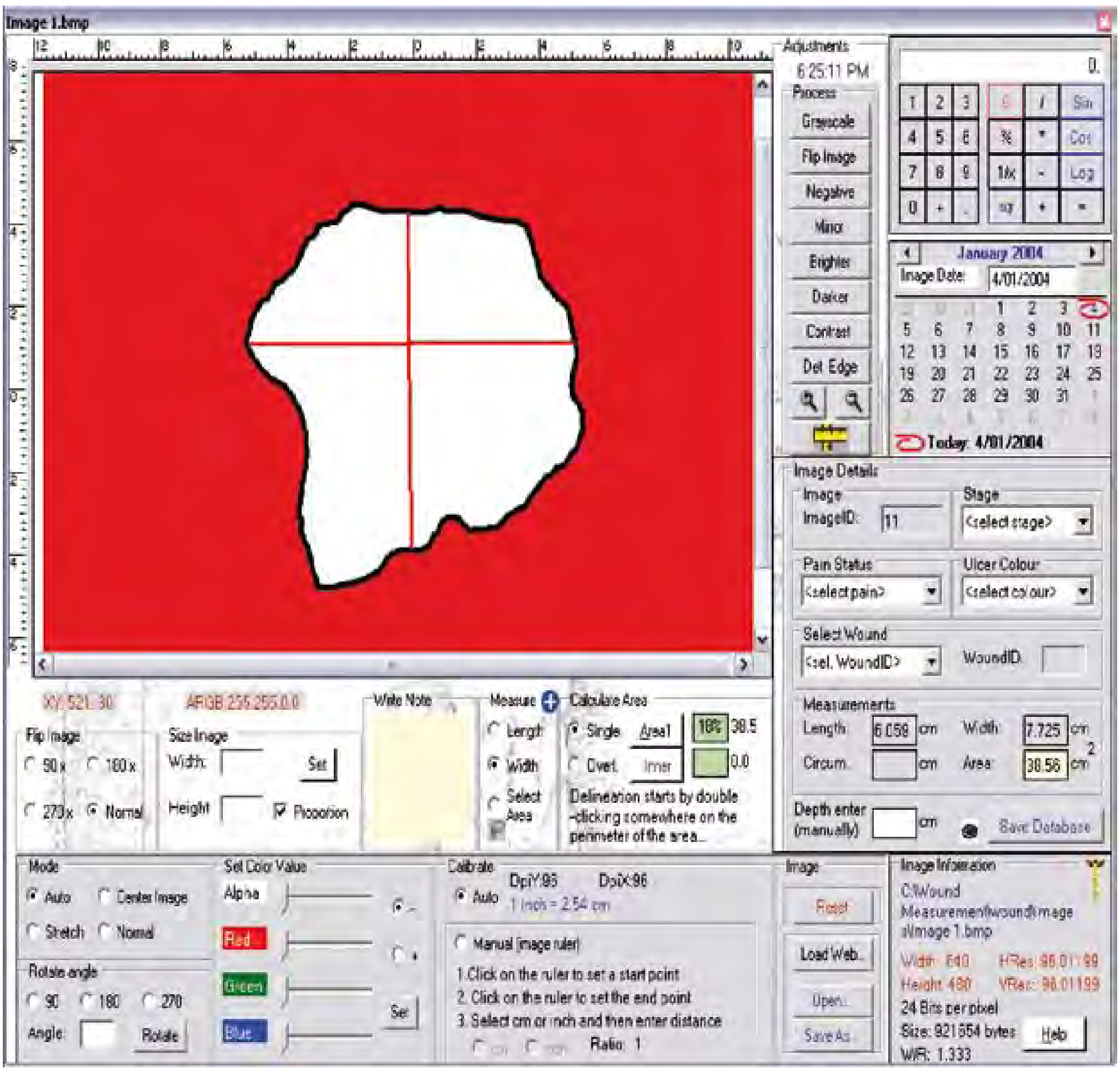
Database design

Figure 4 shows the interface for the wound measurement. The program enables the user to calculate the linear distance (width and length) of an image. The mouse is used to trace the cursor around the image outline (perimeter). The subsequent automatic calculation of the wound size and assessment of the wound's colouring by edge detection and adopting colour filters is more accurate and repeatable (reliable) than manual methods alone. Manual calibration of the measurement can be carried out to increase wound assessment accuracy and reliability.

In addition, at any time, a patient's wound images and image data (Figure 5) may be viewed in chronological order for the purpose of comparison. This provides a visual and informative record of changes to the wound over time (for example, charts can be viewed and information printed). Each image in a patient record includes automatically calculated data for wound size. The user can also select the colour, degree of pain and stage of the ulcer. The degree of pain is divided into three levels; mild, moderate or intense. The more accurate way to define pain is to accept the national or international definitions for loss of tissue and scaling of pain, which can be easily added on the interface and in the database. The system can also record any notes (Figure 6) made by the practitioner.

Finally, the wound measurement software prototype provides all the features necessary to work with databases such as entering new data and modifying or viewing existing data.

Figure 4. Wound measurement user-interface.



Little training would be required as the system is based on the standard MS Windows XP operation system. Figure 7 shows the physician's form.

Figure 8 shows the entity relationship (ER) diagram for the system. The configurations of the MS Access database are that there is a:

- One-to-many relationship between the patient table and the wound table.
- One-to-many relationship between the wound table and the image table.
- Many-to-one relationship between the assessment table and the wound table.

Figure 5. Form wound images.

Figure 6. The image record panel.

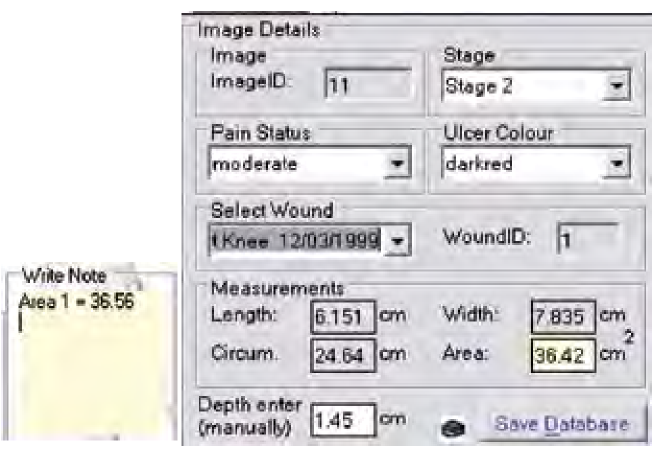
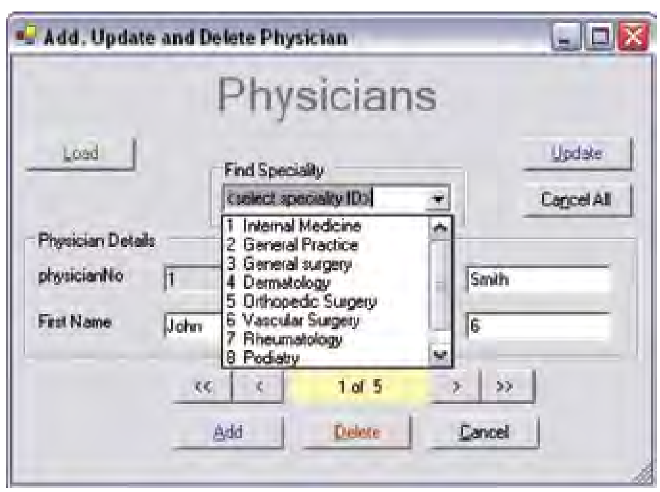


Figure 7. Physician form.



- One-to-many relationship between the physician table and the assessment table.
- One-to-many relationship between the speciality table and the physician table.

Two versions of databases were tested, MS Access and MS SQL server. Figure 9 shows the relationships in six tables from the dbwound.mdb (Microsoft Access database).

Conclusion

In recent years, because of the great interest in using computer systems in wound measurement, database technologies and related programming techniques have become a priority for the development of the digital image based system. Besides the basic structural design, advanced algorithms must be adopted in order to meet the requirements of practitioners. Based on the data stored in the system, the simulated healing procedure could be conducted by artificial intelligent techniques and related modelling methods.

There are a number of areas where the research could be expanded, such as the quantitative and qualitative testing against existing methods, clinical trials using sufficient data and the user (practitioner) testing. Consideration to establish a web enabled database system for wound measurement must be given. All these efforts are aimed at developing a non-invasive, accurate, consistent, efficient and easy to use wound measurement system.

The system described uses modern technologies to improve efficiency, correctness and scalability for wound measurement. The ability to measure the healing rates of wounds is gaining significance in the overall management of wounds. This system proposes an image-storage-capable relational database system that enables the user to extract useful information from the patient record stored in the database relating to the healing progress of the wound.

The primary objective of the research was the development of a software application for wound measurement. The software program developed allows clinicians to measure the healing progress of a wound so an approximate time for healing can be estimated. The wound measurement software program imports images of wounds from all kinds of image files acquired by digital cameras and then uses a unique measurement approach to accurately measure wound sizes.

Figure 9. dbwounds.mdb database.

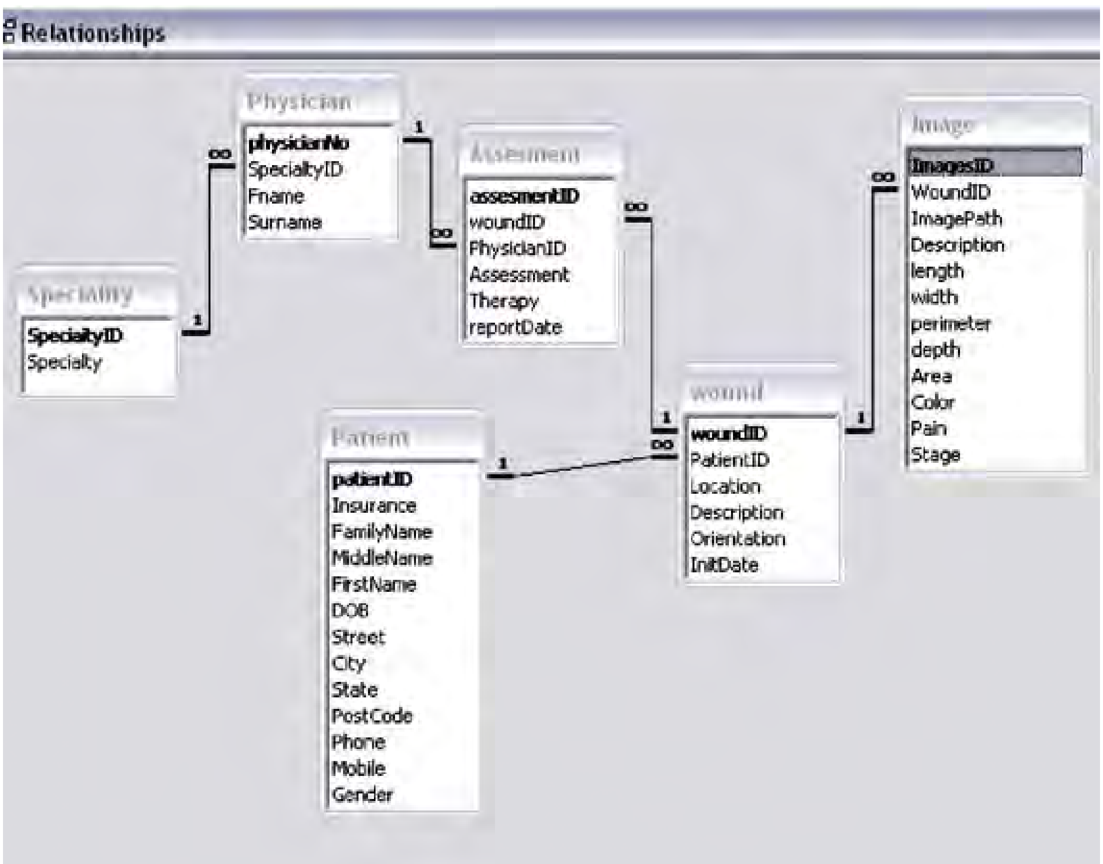
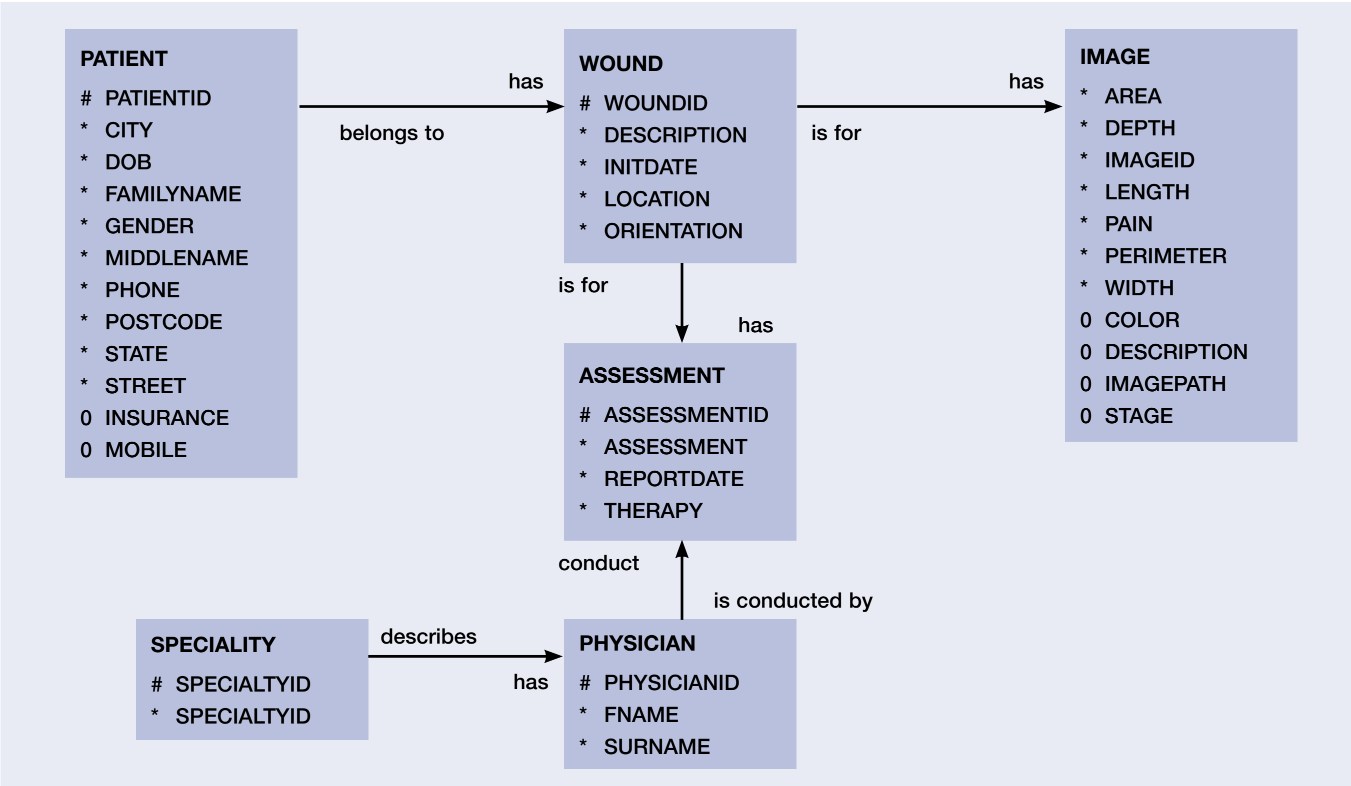


Figure 8. ER diagram.



The MS Access database was used to store and interpret the data. The author proposes that the Microsoft Access database system is simple to use and contains all the essential features necessary to monitor wound healing.

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