Introduction - 1

• Hypertrophic scars are the major long term problem for the post burn-injured patient

• Methods used to treat scars are based mainly around the use of custom made pressure garments and more recently, the use of adhesive and non-adhesive contact media
• Progress in the rational development of therapy methods will be dependent upon the use of more objective assessment

• Objective quantification of skin physical parameters through non-invasive techniques is an essential way to monitor hypertrophic scarring and the efficacy of related treatments
“neither a disease nor a physiological process can be defined until it can be measured”

T. K. Hunt
Scars: morphological characteristics

- Thickness
- Width
- Colour
- Elasticity
- Temperature
- Hardness
Measurements on scars

- Simple
- Accessible
- Non-invasive
- Reliable
- Valid
- Easy to use in the clinical setting
- Reproducible
- Cost effective
Methods to assess scarring

• Ultrasound HF
• Cutometer
• Tonometer
• Laser Doppler
• TcpO₂
• Colorimetry
• Skin temperature
Frequency of assessment

• Too frequent assessment may lead to inappropriate changes in treatment plans
• Infrequent assessment may miss significant deterioration
• Most authors support formal assessment for scars every 4 weeks
Wound healing and TIME: new concepts and scientific applications

Schultz G., Mozingo D., Romanelli M., Claxton K

Wound Rep Reg 2005; 13(4 Suppl): S1-S11
## TIME wound assessment tool®

<table>
<thead>
<tr>
<th>Clinical observations</th>
<th>Proposed pathophysiology</th>
<th>Wound bed preparation non invasive measurement</th>
<th>Effect of wound bed preparation on measurements</th>
<th>Clinical outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tissue</td>
<td>Defective matrix and cell debris impair healing</td>
<td>Debridement assessment: -colour assessment -tissue perfusion - TCP02, colour Doppler, angiography</td>
<td>-promotion of granulation tissue -improved wound bed vascularity</td>
<td>Viable wound tissue</td>
</tr>
<tr>
<td>Infection</td>
<td>High bacterial counts or prolonged inflammation: ↑ Inflammatory cytokines ↑ Protease activity ↓ Growth factor activity</td>
<td>Wound bed and surrounding skin: -temperature -odour -colour -pH</td>
<td>-controlled temperature -reduced odour -vital colour -acidic pH</td>
<td>Bacterial balance and reduced inflammation</td>
</tr>
<tr>
<td>Moisture</td>
<td>Excessive fluid causes maceration of wound margin. Desiccation slows epithelial cell migration.</td>
<td>Leg volume Colour of surrounding skin Surrounding skin trans epidermal water loss (TEWL)</td>
<td>-reduced leg volume -natural skin tones regained -reduced TEWL</td>
<td>Moisture balance</td>
</tr>
<tr>
<td>Edge</td>
<td>Non-migrating keratinocytes. Non-responsive wound cells and abnormalities in extracellular matrix or abnormal protease activity.</td>
<td>2D evaluation: -acetate tracing -digital photography -digital tools and PC software 3D evaluation -probes, moulds -scanning systems</td>
<td>Ability to determine healing progression Wound area is reduced. Wound depth is reduced.</td>
<td>Advancing epidermal margin. Wound stage decreased.</td>
</tr>
</tbody>
</table>
Imaging of scarring

- Laser Doppler imaging
- High frequency ultrasound
- Confocal microscopy
- Derma scanner
Laser Doppler Imaging

Principle: Doppler effect continuously scanned to assess blood movement

Advantages: non contact measurement, large area

Measurement depth: dermis

Applications:
- burn depth
- blood flow in chronic wounds
- scarring
Laser Doppler imaging
Laser Doppler imaging of burn scars: a comparison of wavelength and scanning methods

R. Bray et al. BURNS 2003; 29: 199-206
Imaging of scars before and after treatment
Imaging on Burns
High frequency ultrasound

- A mode - B mode – 3D scanning
- 7.5 - 100 mHz
- rapid, non invasive, epidermis and dermis
- 3D wound bed evaluation
- oedema in venous leg ulcers
- scarring
- preoperative assessment of melanoma
High frequency ultrasound
## Ultrasound Densitometry

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Scar</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>16.13</td>
<td>25.46</td>
</tr>
<tr>
<td>2</td>
<td>33</td>
<td>4.97</td>
<td>28.38</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>2.60</td>
<td>39.87</td>
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<tr>
<td>4</td>
<td>24</td>
<td>6.71</td>
<td>24.89</td>
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<tr>
<td>5</td>
<td>65</td>
<td>5.70</td>
<td>49.96</td>
</tr>
</tbody>
</table>

Bessonart MN. et al. Skin Research and Technology 2005; 11: 185-188
Scar Tissue
and
confocal microscopy
Confocal microscopy is an optical imaging technique that non-invasively images thin sections of tissue. Cellular and architectural detail, including nuclei, microvasculature and blood flow, are imaged in thin, *en face* sections without having to excise and process the tissue as in standard histology. The tissue morphology may be imaged either in vivo or freshly excised (ex vivo).
The VivaScope® 3000 is a hand-held laser confocal microscope capable of video-rate imaging of living tissue at the cellular level. This device potentially can be used as an in vivo or intra-operative device to examine the morphological features and dynamic processes of tissue in real time. The non-invasive “optical biopsy” generated by the VivaScope provides medical practitioners with information that can be used as an adjunct to histology.

- Provides real time, video rate sample assessment
- Images cells in vivo for diagnostic and therapeutic research
- Allows for observation of a site over time to study progression of disease
- Assists in pre-operative and intra-operative margin evaluation
Composite map or VivaBlock measuring 2 x 1.5 mm taken at the top of the reticular dermis shows dense scar tissue (blue arrows) and elongated capillaries (red arrows) adjacent to a normal papillary dermis (green arrows).
Confocal image of the papillary dermis showing scar tissue (green arrows) around the dermal papillae and blood cells (red arrows) flowing through the capillaries.

Field of view is 500 x 500 microns, 1000 x 1000 pixel resolution.
Normal vs. Scar

Confocal images of normal papillary dermis compared to scarred papillary dermis. Field of view is 500 x 500 microns, 1000 x 1000 pixel resolution.
3D scar analysis
3D scar analysis
Conclusions

- Scar measurement is complex and is a skill which requires appropriate instruction, supervision and practice

- Physical measurements are essential in wound healing

- The noninvasive nature of available techniques allows repeated assessment
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