Artificial Skin

Background

The functions of skin are of vital importance to human, and these can be achieved because of the unique structure of skin.

Structure of Skin

- Providing protective barrier
- Reducing the harmful effect of UV radiation
- Acting as sensory organ
- Preventing loss of moisture

Importance of Skin

Medical Problems:

- Skin can be damaged or lost by
  1. Severe burns (By fire, heat, electric current, corrosive chemicals, etc.)
  2. Mechanical skin trauma (Being cut by hard or keen objects, rubbing with rough surface, etc.)
  3. Skin diseases (Skin cancer, skin putrefaction due to infection, etc.)

Therefore artificial skin is needed for transplantation.

- Problems raised without the usage of artificial skin
  1. Severe damage to large area of skin leading to dehydration, and
  2. Infections,
  3. Resulting in death

- Problems raised by traditional skin graft

Traditional skin graft is adopted to replace skin of wounded area by using skin from other parts of patients’ body (such as thigh) or from a different person/cadaver. Problems raised are as follows:

  1. Insufficient skin available for transplantation
  2. Possibility of rejection due to immune response or
  3. Infection during the surgery

So artificial skin can provide essential skin functions and at the same time, have less problems raised compared with the traditional skin graft’s method, which as a whole benefits patients suffering from different degrees of skin loss. Different types of artificial skin are also designed to cater for patients’ needs.

Solutions

The artificial skin aims to substitute traditional skin graft which has more flaws. There are three common types of artificial skins:

1. Spray-on skin
2. Permanent skin graft
3. Temporary skin graft

Spray-on Skin

- Developed from human cells

- Procedures:
  1. Producing enough cells to cover major burns in 5 days
  2. Spraying the cultured cells onto small squares
  3. Putting other skin cell tissue through a meshing machine, meek mesher, and making up into a suspension
  4. Culturing cells for two to three weeks, and creating new skin for patient

Temporary Skin Graft

- To protect the wounds while healing
- Able to be removed after recovery

- Procedures:
  1. Taking cells from unwounded epidermal layer
  2. Culturing the cells as large sheets
  3. Making skin graft from the cell sheets
  4. Applying on wounds to stimulate the growing of new dermis
  5. Waiting until the curing process completes
  6. Removing the protective upper layer

Permanent Skin Graft

- Developed from human cells

- Procedures:
  1. Extracting skin from other parts of body (e.g. foreskin)
  2. Separating skin cells (fibroblast) from dermal layer
  3. Quarantining the cells by testing for viruses and other infectious pathogens (e.g. HIV, hepatitis B and C)
  4. Growing the cells on mesh scaffolding
  5. Thawing, expanding and storing the dermal layer
  6. Implanting it to patients’ wounds
  7. Waiting until new blood vessels grow in the implanted skin. (Approximately one week’s time)
  8. Recovering

There are three types of artificial skin but no fixed formulae are set for different level of skin loss. In other words, artificial skin is used, whether it is only a single type or a mixed of skin grafts, solely on a case-by-case basis and depending on the health conditions of patients.

Acknowledgements

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For different sizes of wounds, different types of methods of healing will be used. For example, (i) When the size of the wound is larger than a normal size of a palm, permanent skin graft will be used, if not, (ii) temporary skin graft will be used instead. For the (iii) spray-on skin method, it is still being studied and thus not being practiced.

The following are 2 case studies using artificial skin:

Case 1: The use of permanent skin graft on a patient with large amount of own skin being removed.

Case 2: The use of the temporary skin graft on a patient with part of skin on leg being debrided (removal of dead, contaminated tissue).

### Cases

<table>
<thead>
<tr>
<th>Cases</th>
<th>Patient</th>
<th>Solution used</th>
<th>Photos before the surgery</th>
<th>Photos after the surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male 5 years old</td>
<td>Permanent skin graft</td>
<td><img src="image1" alt="Fig. 10 Permanent skin graft in culture" /></td>
<td><img src="image2" alt="Fig. 11 Permanent skin graft applied on the wound" /></td>
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<td></td>
<td>Suffering from Necrotizing Fasciitis (a serious infection that causes cell tissue to be rapidly destroyed of right upper limb)</td>
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<tr>
<td>2</td>
<td>Male 62 years old</td>
<td>Temporary skin graft</td>
<td><img src="image3" alt="Fig. 12" /></td>
<td><img src="image4" alt="Fig. 13" /></td>
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<td>Serial change develop ulcer(s) sore area on the outside of the body or on the surface of an organ inside the body which is painful and may bleed or produce poisonous substance at center</td>
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<td><img src="image5" alt="Fig. 14 Wound with bone exposure" /></td>
<td><img src="image6" alt="Fig. 15 The wound is recovering after the apply of temporary skin graft" /></td>
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Although artificial skin can help patients to regenerate their skin or can perform skin’s function, it still has its drawbacks.

### Pros and Cons

For the three types of artificial skin, they share some common advantages and disadvantages compared with that of traditional skin graft. But in general these two methods still possess some strengths and flaws in common, as shown in the last row of the table.

#### Pros

- Possessing regenerating power
- Real skin resemblance
- Unlimited supply
- Reduced scarring
- Low chance of immune response or infection

#### Cons

- Long recovery time
- Expensive
- Fragile
- Inability to be immediate substitute
- Skin functions impairment (sensations, pressure, etc)

Although there are still some imperfections like long recovery time, the ability to regenerate and the unlimited supply of skin really solve many problems that were headaches of surgeons. So it is believed that the advantages actually outweigh the disadvantages to a large extent.

### Future Development

There are still some downsides of artificial skin as mentioned, but there have been many researches being done to rectify the flaws and to perfect this technology.

1. **Growing skin from stem cells in human hair**

   This utilizes the differentiation ability of stem cells, but the technology for monitoring such processes is still being studied.

2. **Producing a fully-functional, lab-produced artificial skin graft**

   It is hoped that artificial skin could be made solely in lab, with which is fully functional and possesses all blood vessels and nerves.

3. **Creating an automated production line process for manufacture**

   The former two form a backdrop under which a manufacture plant could be set up for mass production of skin grafts which cater for everyone where no immune responses would be triggered.

### References