CHAPTER

4

WOUND MONITORING USING A MOBILE APPLICATION

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4.1 INTRODUCTION

Chronic wound is a silent pandemic that has significantly affected 1.67 per 1,000 population, of which chronic leg ulcers alone have a computed prevalence of 1.51 per 1,000 (Popescu et al., 2023). Generally, a wound can be defined as a disruption of the normal anatomical relationships of tissues as a result of injury. Wound healing is a four-step sequence process which is haemostasis, inflammation, proliferation, and maturation. A visual comparison of these stages between normal and chronic wounds is shown in Figure 4.1. These distinctions highlight how normal tissue repair follows a coordinated progression, whereas chronic wounds remain trapped in dysfunctional phases. The successful completion of these four stages is crucial for wound healing, while interrupting one or more steps causes prolonged non-healing wounds, otherwise known as chronic wounds, which fail to proceed through the normal phase of recovery (Raziyeva et al., 2021; Singh et al., 2013). The increase in chronic illnesses, such as heart disease, diabetes, and obesity, is one of the most significant factors contributing to the prevalence of chronic wounds (Theocharidis et al., 2020).

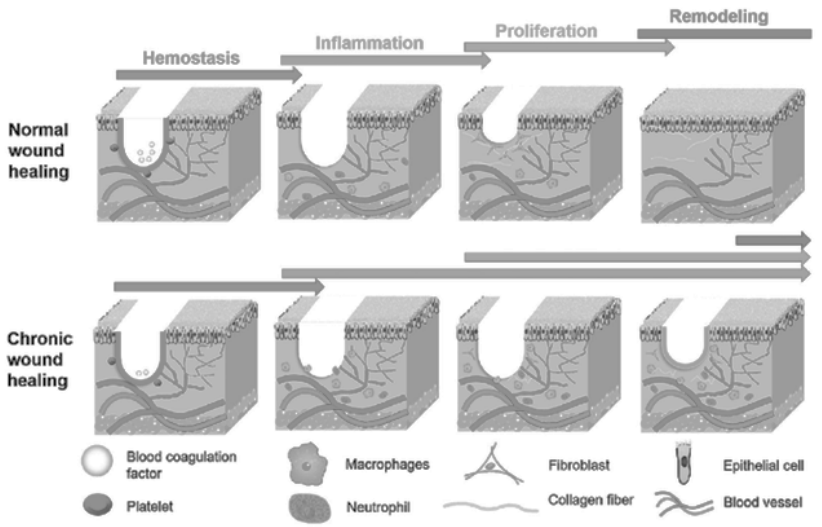

Figure 4.1 Comparison of normal vs. chronic wound healing. Chronic wounds show prolonged inflammation and delayed proliferation, leading to stalled healing compared to normal progression

Conventional wound monitoring relies on physical inspection and microbiological assessment. Physical examination involves the successive removal of bandages, followed by visual inspection by medical professionals to determine the appropriate treatment. This procedure suffers from limited accuracy, as manual approaches increase the risk of human error, leading to misdiagnosis and inefficient treatment decisions. Although microbial assays can provide more conclusive results, they are time-consuming, costly, invasive, and particularly ineffective for detecting deeply invasive bacterial pathogens (Brown et al., 2018; Li et al., 2021; Noushin et al., 2022). Furthermore, both methods often require the removal of wound dressings and frequent visits to healthcare facilities, which can be burdensome for patients and healthcare professionals, as well as escalate costs (Jiang et al., 2023; Monika et al., 2022; Tan et al., 2021). In addition, conventional methods are time-consuming, which may delay the identification of an appropriate treatment strategy by medical professionals and ultimately waste the

optimal treatment window for patients (Chino et al., 2020; Choo et al., 2022; Mohammadieh et al., 2022; Wang et al., 2018). Therefore, there is a need for rapid on-site diagnostic and affordable point-of-care testing equipment to enable effective and early treatment, despite the associated financial burden on patients (Hoyo et al., 2022).

Recently, researchers have identified a plethora of potential biomarkers for real-time monitoring of the wound's conditions. By definition from the World Health Organisation (WHO, 2001), a biomarker is described as any structure, substance, or process which can be measured in the body or its products that can predict or influence the incidence of disease or outcome. In a simpler definition, a biomarker is generally any biomarker that provides an indication of the state of a biological system either qualitatively or quantitatively (Agyare et al., 2018). Despite the numerous biomarkers that can be employed as targets for wound diagnosis, wearable devices have mostly been developed for only a limited number, with pH, temperature and oxygen being the most commonly studied.

The pH within chronic wounds is a significant biomarker which has been proven to be a significant contributing factor along the wound healing process. Generally, skin pH varies between 4.2 and 5.6 while bacterial infection has been proven to slightly increase the pH towards alkaline with a value of 8 due to the release of bacterial metabolites into the wound environments. Initially, the wound undergoes acidosis, with increased oxygen and lactic acid, hence decreasing the pH. Acidosis is required for many cellular activities, such as proliferation of fibroblasts, oxygenation, synthesis of DNA cells, angiogenesis, collagen formation and macrophage activity. Keratinocyte differentiation may be induced at low pH, leading to more rapid wound healing. However, chronic wounds exist in an alkaline environment which promotes bacterial growth by inhibiting fibroblasts, increasing proteolytic activity, and decreasing oxygen supply, leading to healing impairment (Greener et al., 2005; Khan et al., 2015; Liu et al., 2002). Meanwhile, poor vascularisation at the chronic wound sites creates hypoxic conditions, reducing oxygen levels from the normal range of 45–65 mmHg to 0–5 mmHg in the non-