# A Flexible Wearable Interface for the Mechanical Characterisation of Soft Tissue Changes During Disease Progression

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## What is the Problem?

Currently, the NHS spends over **£5 billion** annually to treat skin conditions such as **wounds**, **burns**, and **dermatitis** [1]

Key **diagnostic methods** for such conditions rely on the **visual** and **tactile assessment** of skin to appraise pathological **health** [2]

This **subjectivity** fails to account for the disparities in disease presentation due to variations in **age**, **sex** and **skin colour** [3]

Overall, this has led to a **23% error rate in diagnosis**, putting strain on healthcare systems and decreasing a patient's **quality of life** [4]

## What is our Approach?

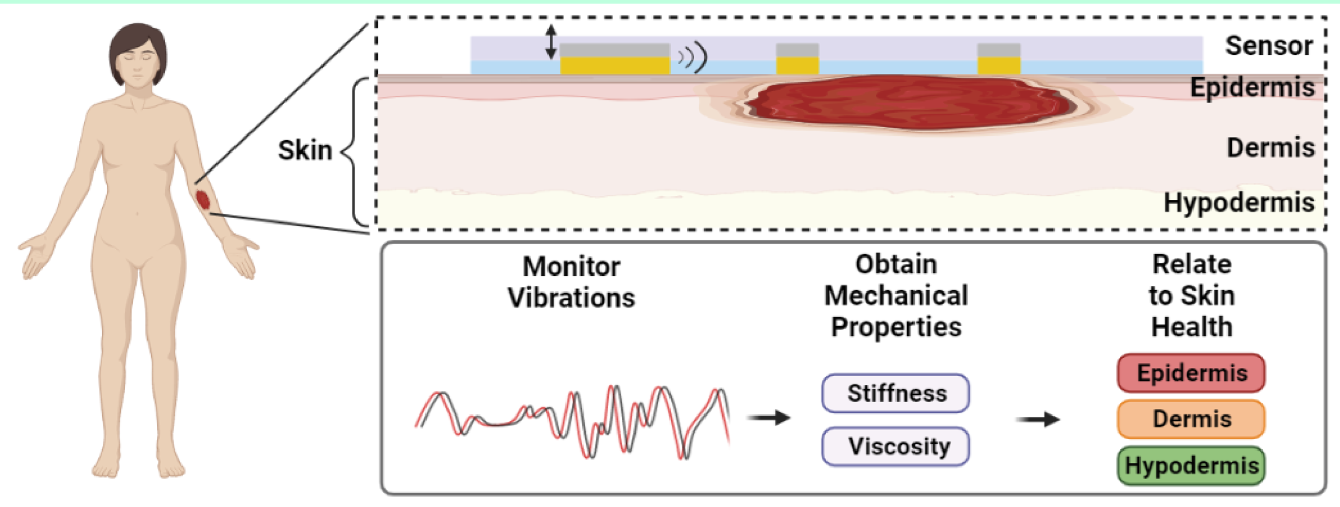


**Figure 1: Graphical representation of our sensor approach, outlining how we can use mechanical measurements to assess tissue health**

- The progression of skin diseases causes local tissue changes such as **inflammation**, **fluid retention** and skin **thickening**
- These changes can be linked to the mechanical properties (**elasticity** and **viscosity**) of the diseased site
- We are using this to enable the creation of low-cost, wearable mechanical assessment devices that can monitor disease over extended time periods

## How Do We Do This?

- Using **millimetre scale** vibrational sensors, we send sound waves through the skin.
- Small receivers are used to "listen" to these waves as they travel.
- The variation in wave speed is then used to characterise the tissue
- Mechanical properties are monitored over time to assess tissue health

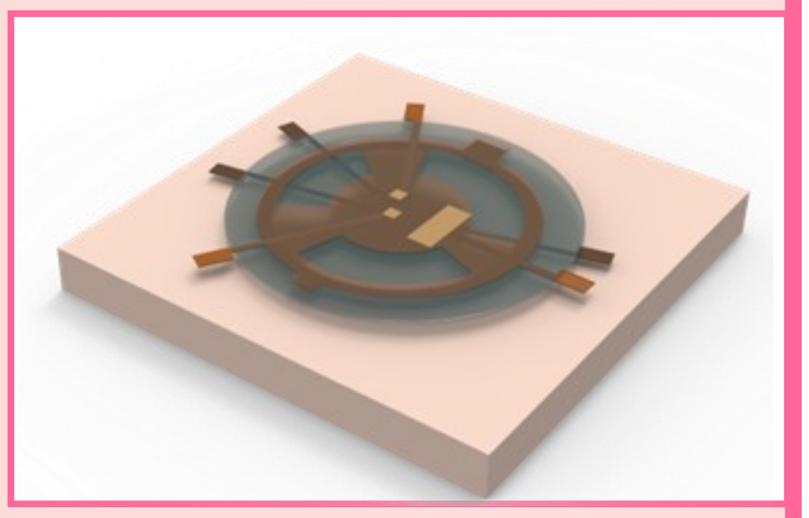

**Figure 2: Rendered model of wearable device place on tissue**

- For example, in **eczema**, the tissue becomes **dry** and **thick** so our sensing mechanism would detect an **increase** in **mechanical stiffness**

- The full sensor assembly is created using very **simple manufacturing** methods and **low cost** materials
- Clinician discussions occurred throughout this process, ensuring physician usability and patient safety
- Tissue-sensor **adhesion** lasts for up to **7 days**, allowing for continuous monitoring both in clinics and at home

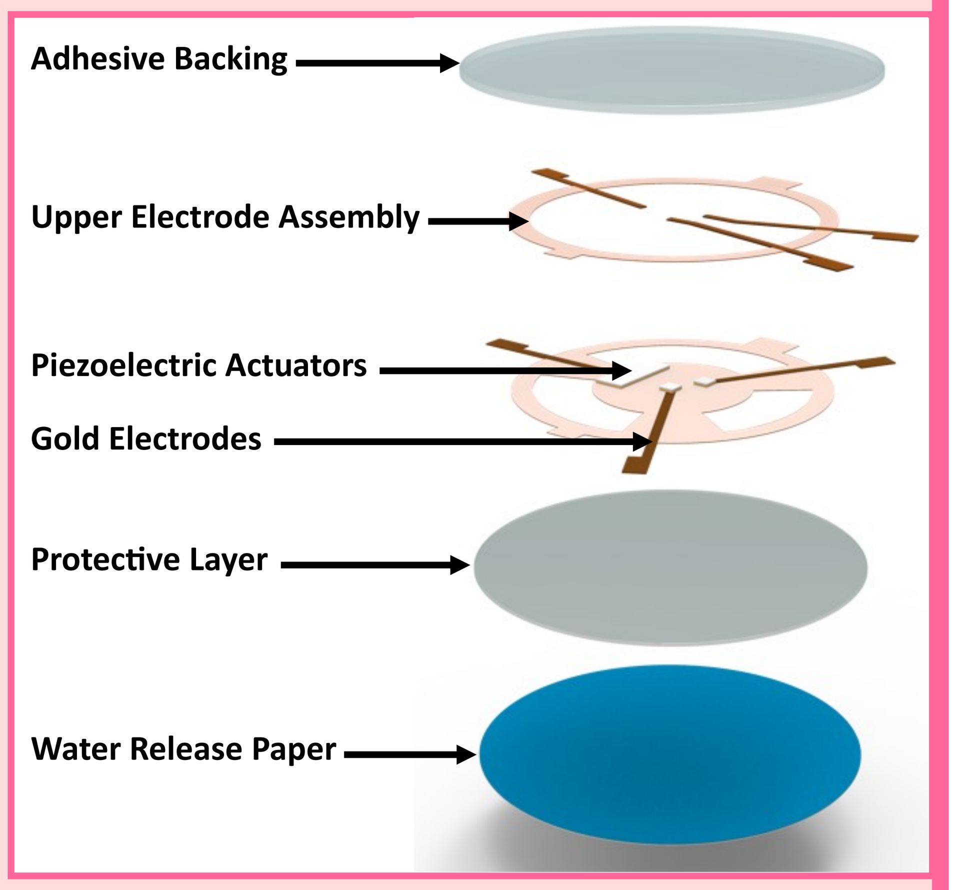


**Figure 3: Exploded assembly of wearable device, showing all key components**

## What Did We Find?

### Understand

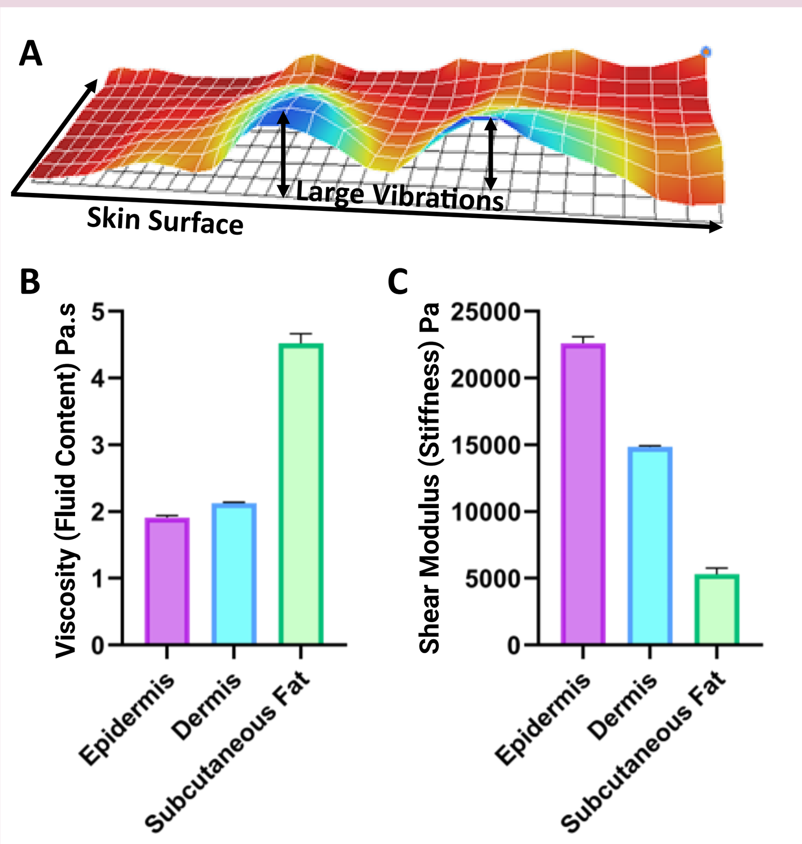


**Figure 4: A) Visualisation of waves travelling through tissue B) Fluid content of each skin layer C) Stiffness of each skin layer**

Using our device we ran various vibration tests on pig skin to optimise our approach. We found that we could measure the elasticity of each skin layer, with results matching reported skin properties.

### Manufacture

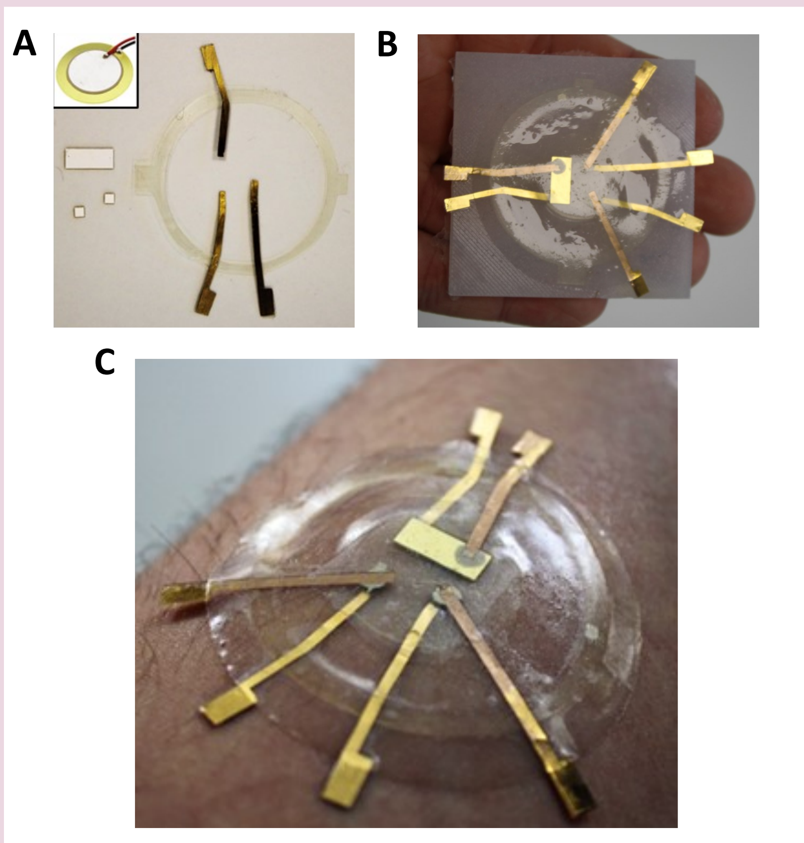


**Figure 5: A) Raw materials used to create sensor B) Prototype sensor placed on silicone C) Final design on human forearm**

Our fabricated sensor **costs less than £1** to make. The simplicity of design and low cost could provide clinicians with an opportunity to continuously monitor disease for a fraction of the current cost.

### Monitor

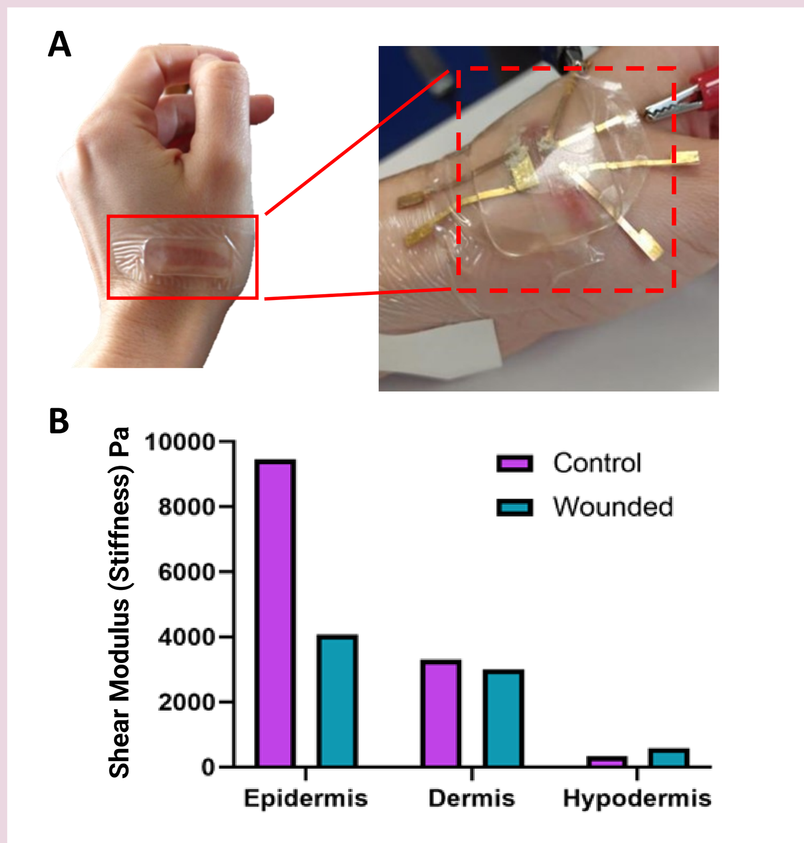


**Figure 6: A) Tested burn showing attached sensor B) Stiffness values of each skin layer on both burned and healthy skin**

Initial human testing has shown our sensors can **detect tissue damage** in wounds. We observed a reduction in stiffness to the top skin layer (epidermis) from a burn, with little damage seen in deeper layers.

## Conclusion

- We have developed a **wearable mechanical sensor** to monitor skin disease over extended time periods using a **non-invasive**, **low-cost** approach
- The sensor is able to obtain mechanical information from **each tissue layer**, with **human tests** demonstrating our ability to **detect damaged and undamaged layers**
- Our solution offers an alternative to current diagnostic methods. Our device has the potential to be used within **NHS facilities or at home**, greatly reducing the cost and strain currently seen by our healthcare service

## References

[1] Guest et al, BMJ Open, 5,12, 2015
[2] Neil H Cox, JRSM, 2006
[3] K. E. Horton, Baylor University, 2013
[4] Seth et al, Cur. Derm. Rep, 2017

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