Sheffield Hallam University | Centre for Sports Engineering Research

Selection and use of skin simulants for player safety assessment

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SportSURF seminar
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Introduction to skin simulants

Used for:

- Product evaluation
- Injury research

Reasons:

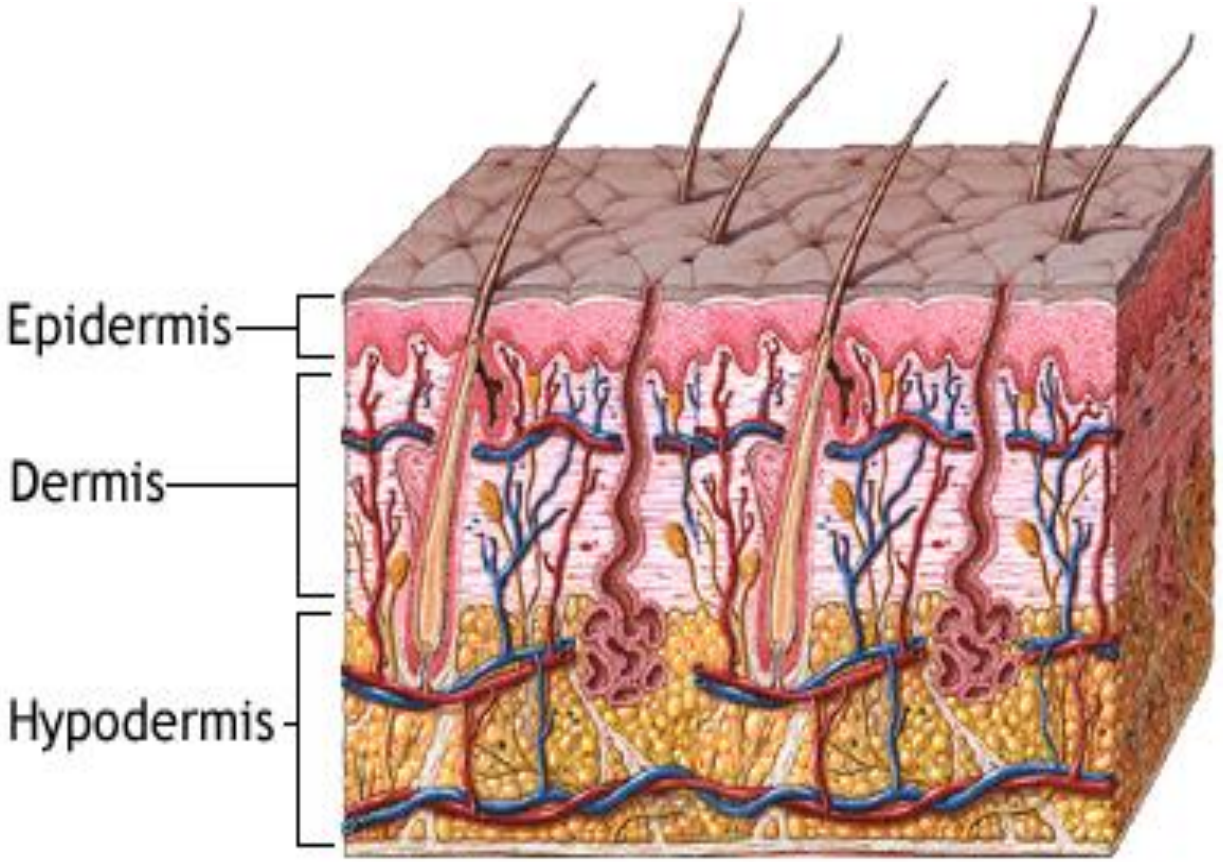
- Ethics
- Reduced variability

Anatomy of the skin

No bleeding

Bleeding

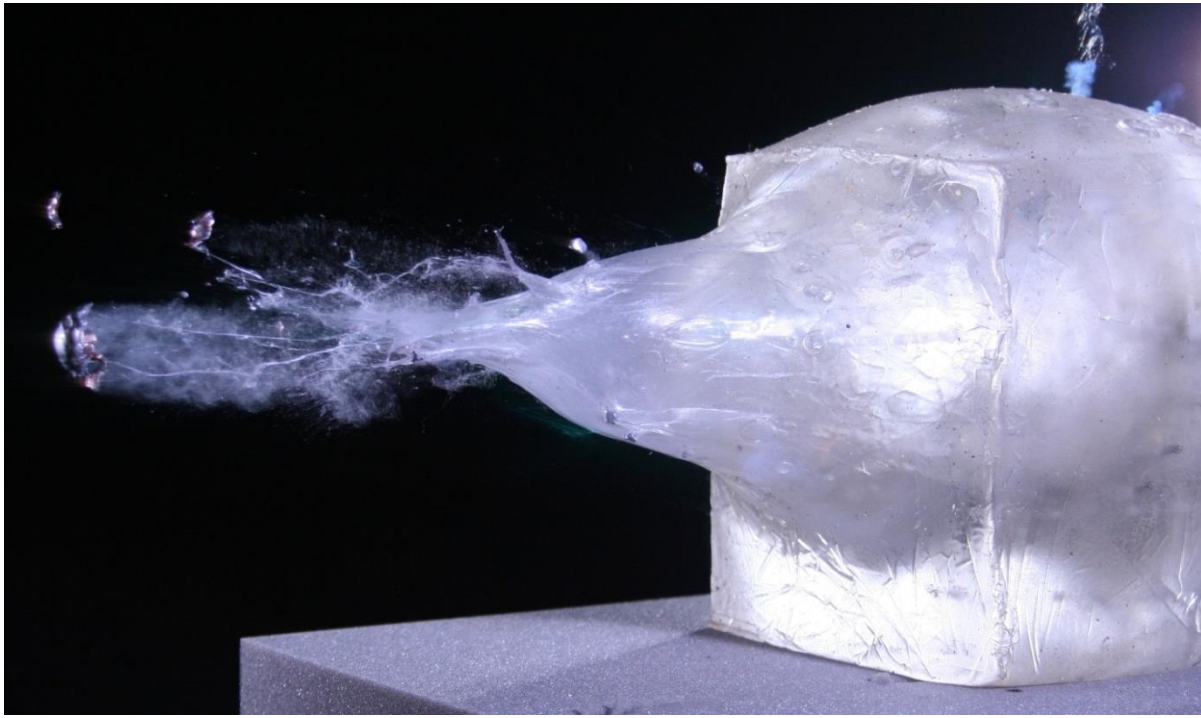
Severe bleeding & scarring



- Injury definition

Body of knowledge: Forensics

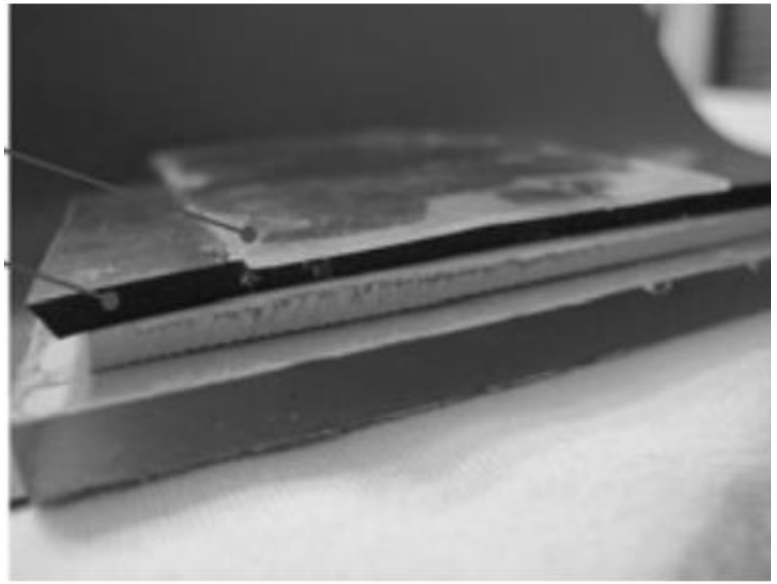
- Ballistics[1]
- Knife impacts[2]
- Blunt force impacts[3]



[1]Jussila *et al.* (2005). Ballistic skin simulant. *Forensic Sci Int,* **150**, 63-71.
[2]Gilchrist *et al*. (2008) Measuring knife stab penetration into skin simulant using a novel biaxial tension device. *Forensic Sci Int,* **177**, 63-65.
[3]Whittle *et al.* (2008). The biomechanical modelling of non-ballistic skin wounding: blunt-force injury. *Forensic Sci Med Pathol*, **4**, 33-9.

Body of knowledge: Sports injury

- Soft tissue engineering[1]
- Skin tissue
  - Blisters[2]
  - Frictional properties[3]
  - Abrasions[4]

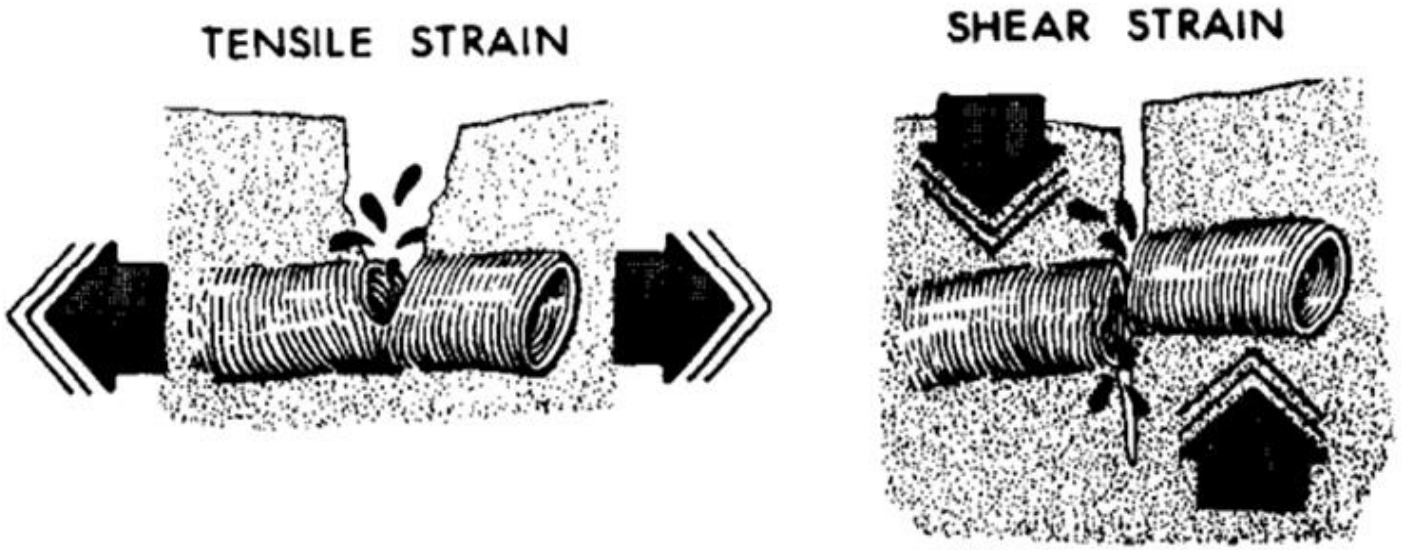


Developed skin simulant by Guerra & Schwartz[2]

[1]Payne *et al.* (2014). Development of Novel Synthetic Muscle Tissues for Sports Impact Surrogates. *J Mech Behav Biomed Mater,* **41**, 357-74.
[2]Guerra & Schwartz (2011). Development of a Synthetic Skin Simulant Platform for the Investigation of Dermal Blistering Mechanics. *Tribol Lett,* **44**, 223-8.
[3]Tomlinson *et al.* (2007). Review of the frictional properties of finger–object contact when gripping. Proc. IMechE, **221**, 841-50.
[4]Tay *et al.* (2016). Addressing skin abrasions on artificial turfs with zwitterionic polymer brushes. *RSC Adv*, **6**(39), 32446-53.

Mechanism of injury (1)

Lacerations are ruptures of the skin caused by impact



Tensile and shear strain, adopted from Viano et al. (1989)

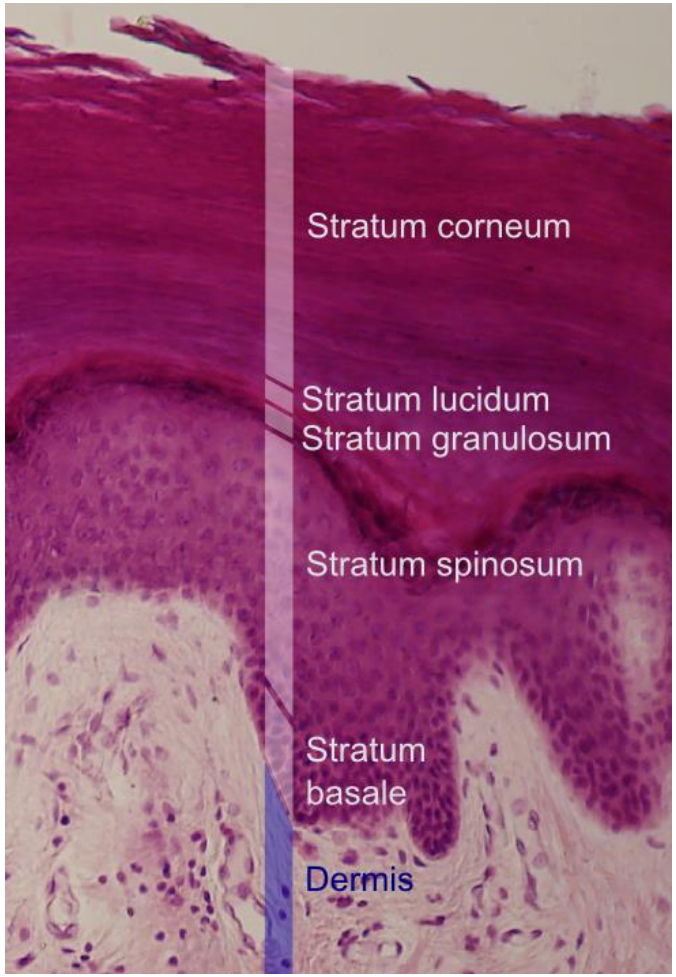
Mechanism of injury (2)

Abrasions caused by rubbing away of outer layers of the skin

Hockey player on water-based field

Mechanism of injury (3)

Friction blisters occur when the bonding between *stratum granulosum* and *stratum basale* layers break



Epidermis layer of the skin

Skin properties

- Friction coefficient
- Tear strength ($kN \cdot m^{-1}$)
- Tensile strength ($N \cdot mm^{-2}$ or MPa)
- Velocity threshold (m/s)
- Elongation at break (%)
- Young's modulus ($N \cdot mm^{-2}$ or MPa)
- Hardness shore A

Biological simulants: PMHS

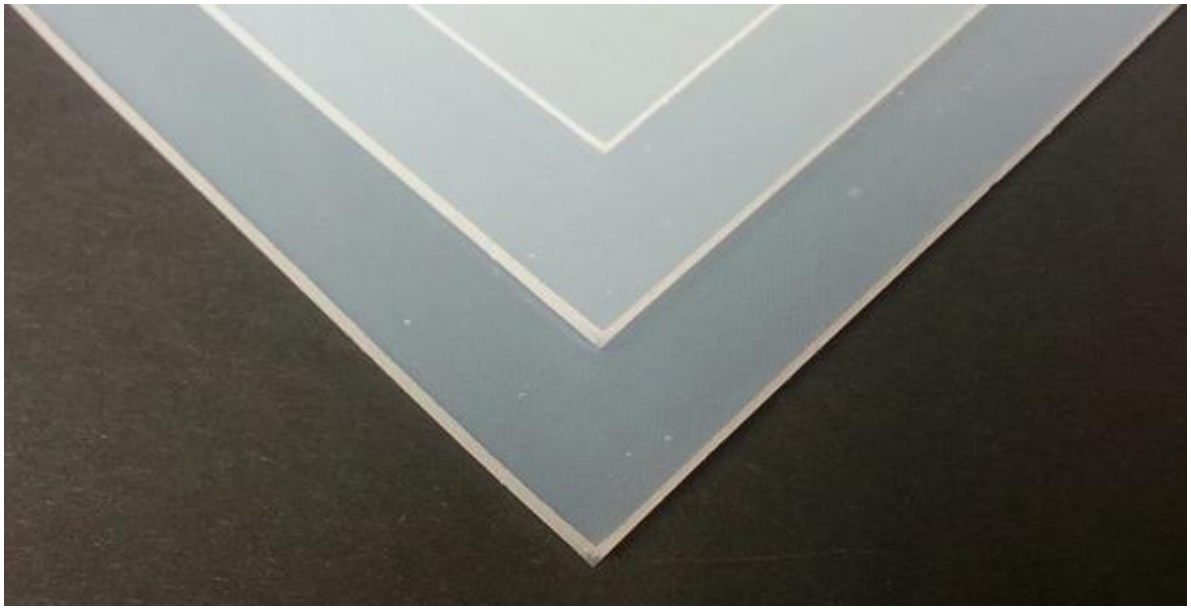
- PMHS (post mortem human subjects) represent *in-vivo* humans best
  - Availability
  - Cost
  - Ethics
  - Time until testing
  - Elderly population

Biological simulants: porcine

- Pig skin is a reasonable simulant
  - Discussion over suitability
  - Low cost
  - Easier to obtain
  - Skin thickness
  - Tougher except for belly area
  - Time until testing

Synthetic simulants

- Silicone rubbers
- Polyurethanes
- Synthetic chamois



Silicone forming

- Silicone usually consist of base and catalyst
- Mix and mould into desired form

Growing air bubbles in vacuum

Mixture after collapsing

Result vacuuming

Vacuumed silicone

Un-vacuumed silicone

Material consistency

- Long term availability of materials
- Publishing relevant material properties
- Laceration injury risk
  - Yet to find most suitable simulant
  - Open to suggestions and collaborations

Conclusions

- Biological tissue is not reproducible enough
- Synthetic simulants have problems with continuity of materials
- Frequently only validated for a specific type of impact (knife, bullet, blister) and results are not necessarily transferable
- Need for sports-impact specific research
  - In soft tissue simulation, this has been done by Payne *et al.*
  - Something similar for skin simulants to reach a wider community consensus would be very helpful

Questions?

- Contact details:

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