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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

CLIN-0036

6 - 10 September 2021
Education Centre
RBWH

A cross-sectional survey of health professionals across Australia and New Zealand to determine what outcome measures are important from a clinical perspective post hand burn injury

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Background

Outcome measures are used in health care to measure clinical practice, efficiencies and determine quality[1]. The Burns Trauma Rehabilitation: Allied Health Practice Guidelines[2] advocates for the collection of outcome measures post burn injuries across different time points post recovery. The guidelines support using outcome measures to collect outcomes that are quantifiable and comparable over time for both individuals and groups[2]. A recent systematic review found 34 studies which reported 32 different outcome measures for use post hand burn injuries with few of the outcomes measures validated for use specifically for hand burn injuries and few were classified as patient reported outcome measures[3]. Many variables influence the collection of outcome measured in practice including clinical reasoning, access to resources and organisational priorities.

Aim

The aim of this study was to gather information from specialist clinicians pertaining to collection of outcomes and methods used in their clinical practice.

Study Design

A cross-sectional study using survey design.

Ethics

Royal Brisbane and Women's Hospital HREC: HREC/18/QRBW/303; University of Queensland HREC: 2018002467; Griffith University HREC: 2019/017

Participants

Allied health professionals who were clinical specialists working with people with hand burn injuries from the Australian and New Zealand Burn Association (ANZBA) and the Australian Hand Therapy Association (AHTA).

Data collection

A purpose designed survey was developed for this study which was distributed via Survey Monkey®.

Results

Participants n= 43. Respondents perceived that hand dexterity (83.7%) was the most important outcome to their patients. Frequently reported assessment methods used by clinicians were patient report of hand function (n=42, 97.7%) and observation (n=41, 95.3%). Time points, assessments and barriers are outlined in tables 1-3 below.

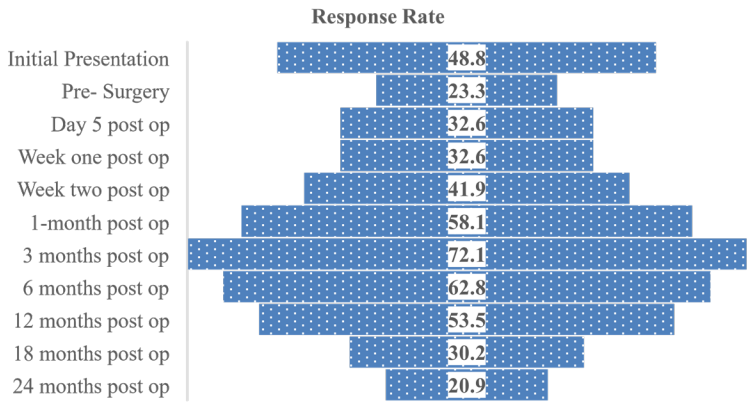

Table 1 Time point for collection of outcome measures

Assessments	Response Rate n (%)
Jamar Dynamometer	40 (93%)
Goniometer	39 (90.7%)
Pinch Gauge	36 (83.7%)

Table 2 Most cited assessment tools

Main Barriers	n (%)
Time Taken to Administer	37 (86%)
Lack of available resources	25 (58.1%)
Time Taken to Analyse the Results	22 (51.2%)
Therapists own Lack of Skill/ Confidence using these assessments	17 (39.5%)
Not Validated for the Burns Population	16 (37.2%)
Feasibility of Assessment	16 (37.2%)
Measurement of Impairment Level	9 (20.9%)
Reliability	6 (14%)
Patient Satisfaction with Scores Over Time	3 (7%)
Other	5 (11.5%)

Table 3 Factors which influence clinicians choice out outcome measure

Respondents reported that patient perception of recovery (n = 33, 76.7%), followed by patient motivation (n=28, 65.1%), support from family/significant other (n =17, 39.5%) and psychological recovery (n=15, 34.9%) were indicators used to measure psychosocial considerations when measuring outcomes post hand burn injuries.

Discussion

Respondents reported that hand dexterity, scar cosmesis, full active range of motion and hand strength were outcomes of importance to the patient. Measurement of hand dexterity and hand strength are included in assessment recommendations for hand function post burn injury[2]. Strength and dexterity are important as they correlate with work performance and daily tasks[4]. Focus on regaining range of motion of the hand post burn injury is essential component of recovery[4].

Conclusion

The findings of this study suggest that clinicians collect some outcome measures in their routine practice using both informal and formal assessments. Barriers identified when using outcome measures include a lack of time and a lack of reliable/ validated tools to measure outcomes post hand burns. There is a need for further studies in this area.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

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Exploration of outcomes of severe hand burn injuries from the perspectives of the consumers

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Background
Burns injuries interrupt both physical and psychological domains of daily life[1]. Burn injuries to the hand impact how an individual interacts with the world around them across both physical and social environments[2]. Deep dermal and full thickness burns require surgical management to achieve timely wound closure and intensive therapy to prevent contracture deformities[3]. Recovery from injury is an individualised process therefore understanding the perspective of the consumer will enhance our awareness of what outcomes are important to attain[4].

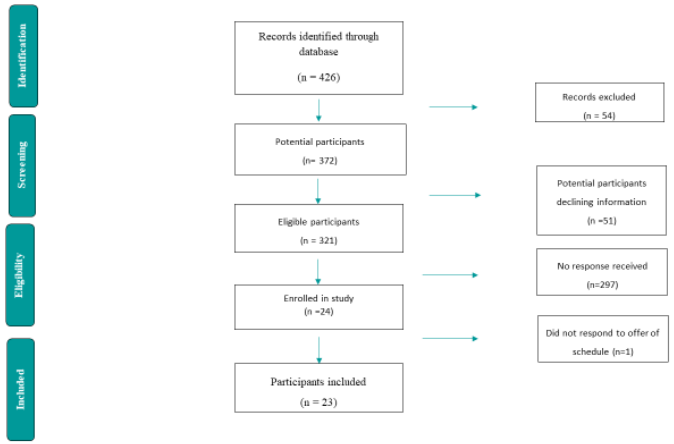
Aim
The aim of this study was to explore the lived experience of hand burn injury outcomes.

Study Design
Interpretive description was used to guide a qualitative approach allowing for a in-depth exploration of semi structured interviews.

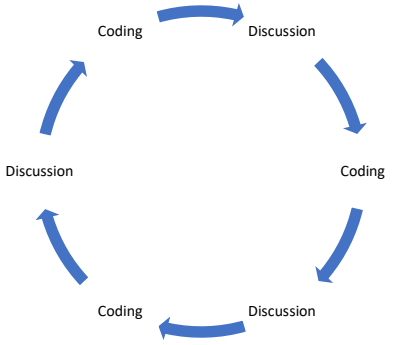
Ethics
Royal Brisbane and Women's Hospital HREC: HREC/18/QRBW/303; University of Queensland HREC: 2018002467; Griffith University HREC: 2019/017

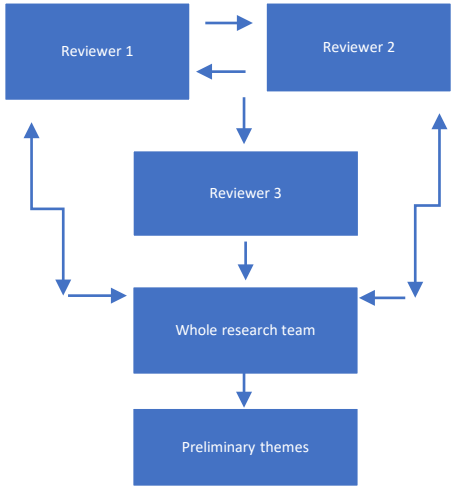
Inclusion
> 18 years, minimum of 18 months post injury, deep dermal/ full thickness hands burns requiring surgical management.

Procedure
Potential participants were contacted by a staff members not involved in the study to determine if they would like to receive a study pack. A four week return time frame was provided. Upon receipt of a completed consent form, participants were enrolled in the study. Face to face and telephone interviews were offered. Interviews were audio recorded and transcripts were transcribed verbatim.



Data Analysis





Findings

Discussion
Measurement of individuals experiences provides insight into the perspectives of individuals accessing our health care systems[4]. The time taken for recovery was an element which appeared through all themes. Participants discussed the need for mastery with or without assistance as an important element of the recovery process. Early rehabilitation positively influences long term outcomes as described by Yohamman et al. [5] Time influence both physical and psychosocial recovery with participants accepting changes over time to varying degrees. Upon leaving the acute care setting, participants discussed becoming more self confident and with increased self management, this is similar to the findings of a study by Kamolz et al.[6] Participants reported a strong awareness of their reliance and the resulting burden on others during their recovery period. Kool et al. (2017)[7] described this as vulnerability and resilience post burn injury. As time past this burden also reduced.

Conclusion
The findings of the study suggest that hand burns interrupt physical and psychosocial recovery. The impact of a hand burn injury changes over time. Recovery is gradual. There is a need for a burn's specific outcome measure which measures performance which is sensitive to change over time.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0005

6 - 10 September 2021
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Transform the Uniform: Designing Fashion for the Hospital of the Future

Mathilde R. Desselle[1,2,3], Icaro Ibanez-Arricivita[4], Alethea L. Blackler[4], Maria A. Woodruff[2]

Abstract

Design students worked collaboratively with healthcare workers to create a concept-driven collection of hospital wear. The study aims were:
1. to identify **challenges with hospital clothing**;
2. to engage students in a **real-world design challenge**;
3. to gather **reactions** to the collection at **fashion shows.**

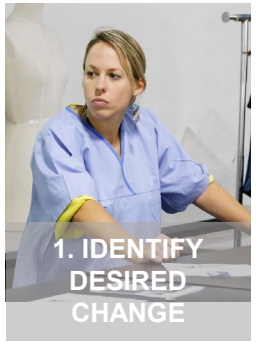
Methods

- Survey and literature review to identify challenges with current hospital clothing
- 6 weeks intensive design with QUT fashion students DFH501 + student survey (12 students)
- Evaluation at fashion shows (Herston Health Precinct and QUT Robotronica 2019)
- Ethics: QUT HREC 1900000707

Results

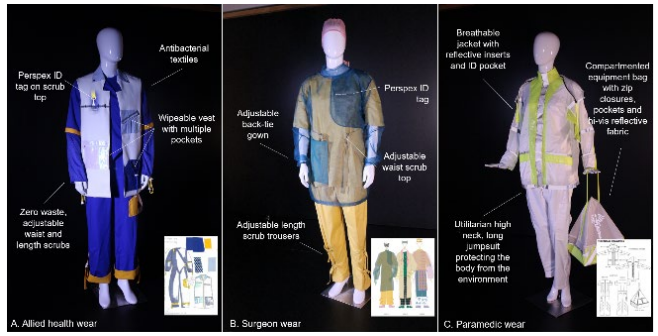
- HCW clothing challenges: **poor fit** and lack of means for name, qualifications and role **identification**
- Patient clothing challenges: **dignity, sizing and colour**
- Design and manufacturing of **capsule collection of 22 outfits,** and modelling by HCW, scientists and patients
- **27% of surveyed HCW would wear it**: practicality and infection control concerns.
- **48% of surveyed patients would wear it**: praising modernity and good coverage of the body.

Results and iterative design



Discussion

- Opportunity for shift in **patient wear: brighter, two-piece, smart closure systems**
- **Sizing** options for various body types, **ID display** and **pockets** are desirable in **HCW wear**
- Students praised opportunity to think **fashion for the healthcare industry** and to **develop market-ready skills**
- Next step: transfer into hospital context and consider practicality for various professions and settings, laundering and infection control



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Mathilde R. Desselle, Icaro N. Ibanez-Arricivita, Alethea L. Blackler & Maria A. Woodruff (2021) Transform the uniform: designing fashion for the hospital of the future, International Journal of Fashion Design, Technology and Education, 14:2, 232-242, DOI: 10.1080/17543266.2021.1915393

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0020

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Patient Engagement in Virtual Reality as an Adjunct to Upper Limb Burns Rehabilitation

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Background

The rehabilitation of a burn injury is an integral part of burn treatment and is an extended process, continuing for months after the initial event. For patients with injuries due to burns, participating for the duration of therapy is a challenge, as an increased range of motion is often associated with higher discomfort or pain. The motive behind a virtual reality system for occupational therapy upper limb rehabilitation is to provide the **opportunity for participation in meaningful activity** for persons that have suffered from a burns injury.

Virtual Reality Game Interventions

The **Oculus Quest** is an immersive **virtual reality headset** hosting the game, Beat Saber. The game requires the user to 'slash' music beats using the upper limbs. The movements required by Beat Saber and **Nintendo Wii Sports** are similar and upper limb dominated, where specific movement patterns resemble those used for burns occupational therapy.

Primary Aim

To enhance the quality and meaningfulness of rehabilitation, and to compare patient satisfaction and engagement in immersive and non-immersive virtual reality.

Secondary Aim

To propose and investigate tools to improve the way movement is assessed and to consequently provide kinematic evidence for patient engagement.

Ethical Approval

Ethical approval was granted by the RBWH HREC. HREC/2020/QRBW/70050

Methods

This project was a pilot repeated measures study. Participants recruited were current in-patient and out-patients of the **RBWH Occupational Therapy Upper Limb Rehabilitation Group**. Five (5) patients were asked to complete a virtual reality game therapy protocol whereby they interacted with the non-immersive game Nintendo Wii and the immersive virtual reality headset Oculus Quest.

To qualitatively measure patient experience of interaction with virtual reality games, a user satisfaction questionnaire was distributed. To quantify the amount of engagement exhibited by patients during the study, the video-based motion capture software **OpenPose** was used.

Qualitative Results

Patients recorded that the Oculus Quest was **"a lot of fun"** , beneficial for **"moving their arms"**, and **"good to do something different with technology to help the rehabilitation process".**

Some reported the Nintendo Wii as **"very beneficial"** and a **"great system for rehabilitation"**.

Questionnaire Results

Question	Oculus Question n = 5		Nintendo Wii n = 3	
	Mean	SD	Mean	SD
Q1. Did you enjoy your experience with the system?	5.00	0.00	4.67	0.58
Q2. Were you successful using the system?	4.20	0.45	4.33	0.58
Q3. Were you able to control the system?	4.40	0.55	3.33	0.58
Q4. Is the information provided by the system clear?	4.80	0.45	4.33	1.15
Q5. Did you feel discomfort during your experience with the system?	4.20	1.67	4.33	1.15
Q6. Do you think that this system will be helpful for your rehabilitation?	4.60	0.89	4.67	0.58
Q7. Did you feel nausea during your experience with the system?	4.80	0.45	5.00	0.00
Q8. Did you feel fatigue during your experience with the system?	4.80	0.45	4.00	1.00
Q9. Did you feel stiffness during your experience with the system?	4.80	0.45	4.33	0.58
Q10. Were you able to comfortably hold the hand-held remotes?	4.80	0.45	5.00	0.00

Discussion

The use of Oculus Quest was mostly successful across the patient group. Patients early in their rehabilitation had considerably limited range of motion and consequently had lower levels of participation at slower paced games. Patients further along in their progression of rehabilitation were able to actively participate at higher game speeds to complete multiple rounds of the Beat Saber levels.

The questionnaire results consistently **favour the use of the Oculus Quest** when compared to the Nintendo Wii in terms of **enjoyment, control, stiffness to the upper limb,** and **level of fatigue.**

Conclusion

The results obtained **support increased patient satisfaction and engagement in rehabilitation programs with use of the Oculus Quest** headset to play the immersive virtual reality game Beat Saber. Consequently, the use of immersive virtual reality games should be employed as a therapy tool in the Occupational Therapy Upper Limb Burn Rehabilitation Group. Furthermore, the use of OpenPose in this clinical environment demonstrates the greater potential for use of the software as a non-invasive, affordable, and effective method for kinematic analysis and quantification of therapy induced movements for patients.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

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6 - 10 September 2021
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Developing a virtual reality rehabilitation system with hand tracking

Aaron Coox[1], Dr Antonio Padilha Lanari Bo[1], Andrea McKittrick[2], Sue Laracy[2], Giovanna Tornatore[3], Mathilde Desselle[4]
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Abstract
This study investigates the application of hand-based exercises in VR to occupational therapy upper-limb rehabilitation. Hand tracking on the Oculus Quest 2 is used to support realistic interactions without controllers or gloves.

VR Rehabilitation

VR can increase rehabilitation effectiveness

Gamification benefits motivation, intensity, and engagement

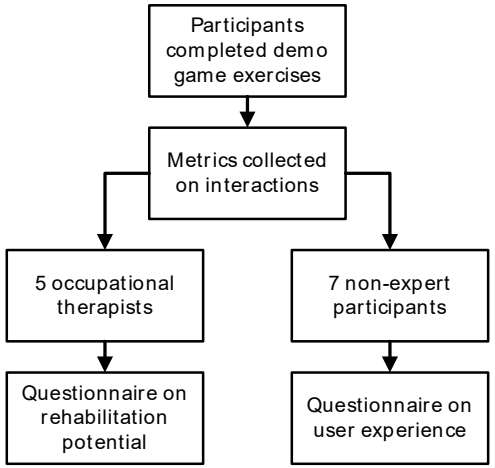
Exercises in VR translate to real-world improvements

Allows for customised exercises, difficulty, and metrics per user

Methods
A VR hand-tracking-based interaction system was developed that supports various hand interactions including grasping, pinching, and gesturing to complete virtual activities. This system has been created to facilitate future development of patient and theme-specific VR games for hand rehabilitation.

User Testing
A proof-of-concept rehabilitation game was tested with non-expert (n=7) and expert occupational therapy (n=5) participants. Metrics were collected and participants filled out a short-response and Likert-scale questionnaire.

Instructions were delivered through an in-game screen. Participants completed tasks including:
- Picking up and placing objects of various shapes and sizes.
- Pinching bubbles between fingertips.
- Opening doors with handles.
- Tracing paths with shoulder movement.
- Making complex hand gestures.
- Pressing buttons.



Environment Interactions

Game Environment

Results
- **100%** of expert participants agreed the system had **potential for rehabilitation**.
- A System Usability Scale of 74.5 (Expert) and 88.92 (Non-Expert) indicates **very high usability**.
- **Recommended patient populations include stroke, burns, hand therapy, chronic pain, and orthopedic.**
- **30% of interactions failed** due to user error or tracking limitations.
- **Lack of physical feedback** and **tracking error** were identified as primary limitations.
- **100%** of participants found the system **engaging**.

Discussion
- Visual hand representation, audio-visual interaction cues, and 3d object design were vital to improving interaction quality and reducing confusion.
- Tracking error varies per user and can lead to frustration. Software filtering can mitigate this.
- In future works, this system will be tested with target patient populations in a functional environment.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0026

6 - 10 September 2021
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3D printing of personalized radiation shielding for treatment of skin cancers

S Crowe [1,2,3,4], W Li [3], S Cleland [5], E Simpson-Page [1], N Cassim [1], S Maxwell [1], R Wilks [1,2,3], P Charles [2,3,4], T Kairn [1,2,3,4]

1. Cancer Care Services RBWH. 2. Herston Biofabrication Institute. 3. University of Queensland, 4. Queensland University of Technology. 5. Metro South

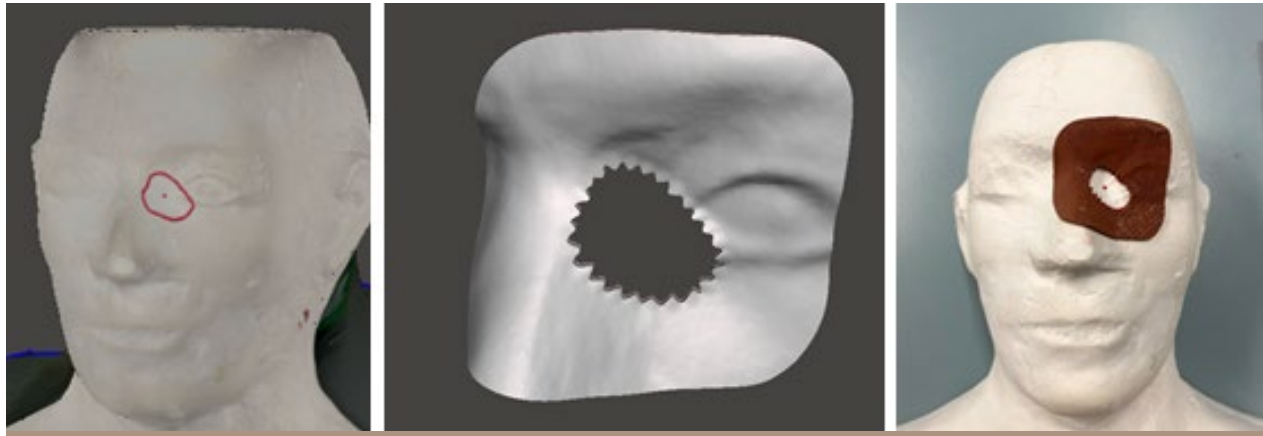
Purpose

Kilovoltage (kV) radiotherapy is used for treating superficial cancers, e.g. basal and squamous cell carcinomas. kV treatments require shielding to be used to conform the radiation beam to the target tissue, and this may need to be patient-matched for sites around ears, nose and eyes.

Historically these have been made by moulding lead sheeting to the patient anatomy. Many departments want to remove lead handling due to material toxicity. One alternative to lead is the use of 3D-printed high-density plastic-metal composites.

Method

Two 3D-printable composites were investigated: PLA/tungsten and PLA/copper. The thicknesses required for shielding were calculated using open source radiation modelling software, and verified with radiation detectors. To demonstrate potential clinical use, a shield was prepared for an anthropomorphic phantom, based on both computed tomography (CT) images and 3D scans.



Results and conclusion

The thicknesses of shielding of the composite materials for energies used in superficial radiotherapy ranged from 0.3 to 0.8 mm of PLA/tungsten and 2 to 8 mm of PLA/copper. Shields of these thicknesses can be 3D printed efficiently. An example shield is shown above. This work is described in more detail in "Predicting the required thickness of custom shielding materials in kilovoltage radiotherapy beams", Physica Medica vol. 81, pp 94-101.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0027

6 - 10 September 2021
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Application of 3D scanning technology in radiation oncology

S Crowe [1,2,3,4], J Luscombe [1], T Poroa [1], S Maxwell [1], S Cleland [5], T Kairn [1,2,3,4]

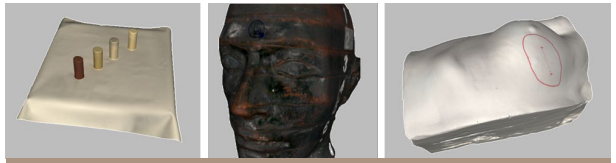
1. Cancer Care Services RBWH. 2. Herston Biofabrication Institute. 3. University of Queensland, 4. Queensland University of Technology. 5. Metro South

Purpose

Patient-matched medical devices are used in the treatment of superficial disease in radiotherapy. They include shielding (to decrease healthy tissue dose), bolus (to increase skin dose), and applicators and templates (to position the radiation source).

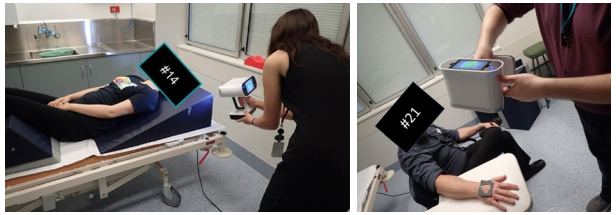
Historically these have been made manually by patient moulding. 3D printing allows them to be made from computerised models. 3D scanners are a potential safe, cost-effective solution to obtaining those models.

This project aimed to characterise the clinical suitability of 3D scanners for radiotherapy devices, and to develop a clinical workflow for our patients.



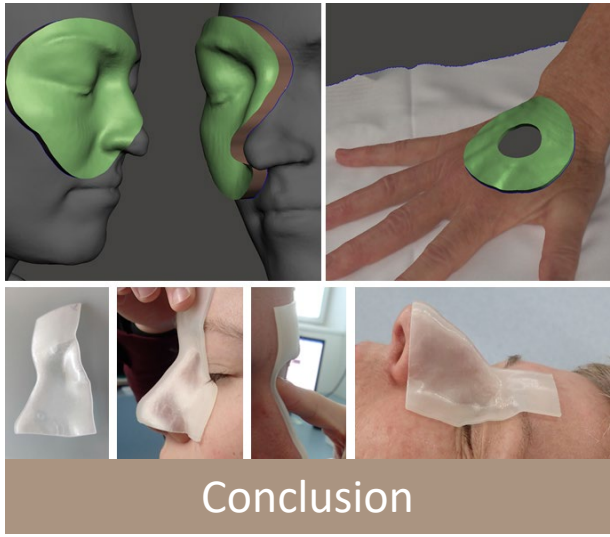
Method

The 3D scanner was commissioned by scanning objects of known sizes, and variable shapes, surfaces, and colour tones, and checking results. We then acquired 173 scans of 26 volunteers, in different positions. The volunteers had self-reported variations in skin and hair tone, height and weight. Thin "shell" devices were prepared for volunteers.



Results

The mean scan time was 3 minutes. The scanner was easy to use, and produced sub-millimetre accurate 3D models of participants. The test devices produced using the models fit participants with minimal air gaps present, ensuring accurate delivery of the therapeutic dose of radiation.



Conclusion

An alternative to the existing use of CT imaging for device design was developed, and has subsequently been successfully used within Cancer Care Services in the preparation of a radiotherapy treatment.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

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6 - 10 September 2021
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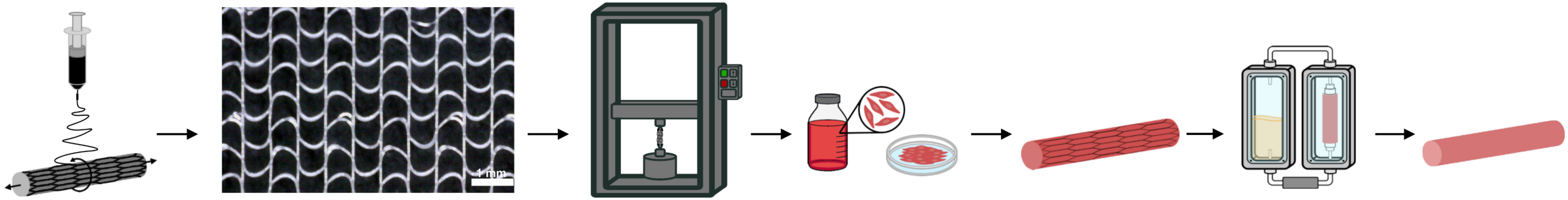
Biofabrication of Small Diameter Tissue-Engineered Vascular Grafts (TEVGs)

Angus Weekes[1,2], Nicole Bartnikowski[1,3], Nigel Pinto[2,4], Jason Jenkins[2,4], Christoph Meinert[1,2], Travis Klein[1]

[1] Centre for Biomedical Technologies, Queensland University of Technology; [2] Herston Biofabrication Institute, MNHHS;
[3]The Prince Charles Hospital, MNHHS; [4]Royal Brisbane and Women's Hospital, MNHHS

Purpose: Current strategies for revascularisation of small diameter (<6 mm) blood vessels frequently fail due to various clinical complications, and with cardiovascular disease (CVD) the leading cause of patient mortality globally (WHO, 2020), there is an urgent need for improved treatment options. The rapid advancement of tissue engineering, enabling the biofabrication of vascular grafts which remodel *in vivo*, promises a paradigm shift in CVD management. This project aims to develop biomimetic TEVGs using melt-electrowriting (MEW), a specialised additive manufacturing technology, to produce highly porous scaffolds for tissue culture. **Here, we present a project overview, focusing on scaffold production and mechanical testing.**

Methods: Melt-electrowriting (MEW) has been employed to fabricate sinusoidal scaffold geometries with ~200 µm pore sizing and 10 µm fibre diameters, from biocompatible, biodegradable PCL. Mechanical testing is underway to compare scaffold performance with existing grafts, focusing on radial compliance, which is critical to long term patency. Current synthetic grafts exhibit poor compliance, however preliminary mechanical testing of the scaffolds produced thus far, which are designed to compliantly expand, indicate promising results. Subsequently, we aim to seed and culture vascular cells onto scaffolds under physiological conditions in pulsative bioreactors, to produce TEVGs suitable for implantation.



Melt Electrowriting (Fabrication of polymeric scaffold)

Geometric Analysis (Imaging & analysis of scaffold geometry)

Mechanical Testing (Testing of scaffold mechanical properties)

Cell Expansion (Patient-derived cells or cell lines)

Scaffold Seeding (Cell seeding via various techniques)

Tissue Culture (Pulsative dynamic tissue culture)

Engineered Vessel (Suitable for implantation or further treatments)

Conclusions: While we continue to perform experimental work to assess the mechanical performance of the scaffolds produced via MEW, preliminary findings are promising, with cell studies to provide further indication of the suitability of the scaffolds produced. This application of MEW technology has potential to greatly improve small diameter vascular bypass surgery, through the fabrication of clinically relevant, vascular tissue engineered constructs with mechanical characteristics which mimic native tissue for improved patency *in vivo*.

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HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0038

6 - 10 September 2021
Education Centre
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Skin Organoid: An Advanced Tool for Human Skin Development and Reconstructive Surgery

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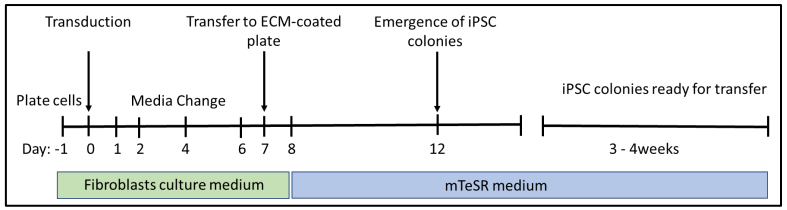
3- Royal Brisbane and Women's Hospital, Metro North Hospital and Health Service, Brisbane, Australia.

Introduction: The application of stem cells to derive functional skin for the purposes of disease modelling, study developmental pathways or regenerative medicine is a research area of great interest. Recent studies showed success in generating some skin cells/layers from human induced pluripotent stem cells (hiPSCs), but creating skin containing functional appendages, such as hair follicles and sweat glands, is still an unmet challenge in the field.

Aim: We aim to develop a protocol for generating skin organoids from hiPSCs.



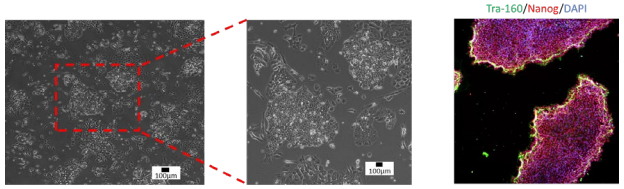


***Figure 1**: Generation of hiPSCs from human skin fibroblast cells using CytoTune 2.0 sendai reprogramming kit (Thermo Fisher). hiPSCs colonies express telomerase activity (Tra-160) and Nanog.*

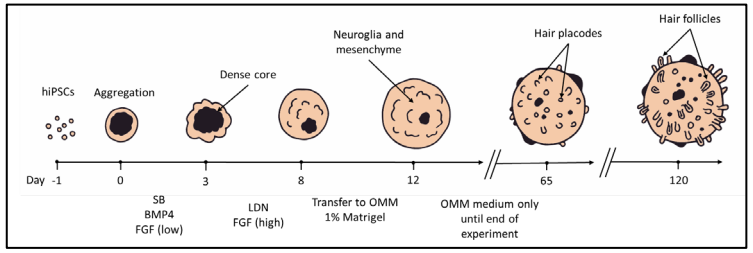


***Figure 2** : Overview of skin organoid protocol.*

Results: By modulating the FGF/BMP pathway in hiPSC, we could generate skin organoids that recapitulate the structure of human skin.

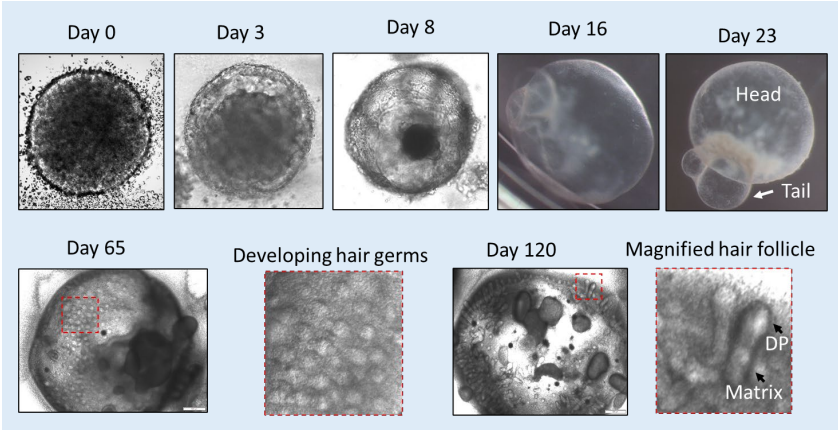


***Figure 3**: Differentiation of hiPSCs into skin organoids. By day 65 hair germs were developed and generated pigmented hair follicles by day 120 (**Figure 3**). DP: dermal papilla.*

Results: Immunostaining analyses demonstrated the expression of skin key markers (Keratin 14, 15 and 17, Loricrin), neural (Tuj1) and dermal papilla (Sox2).

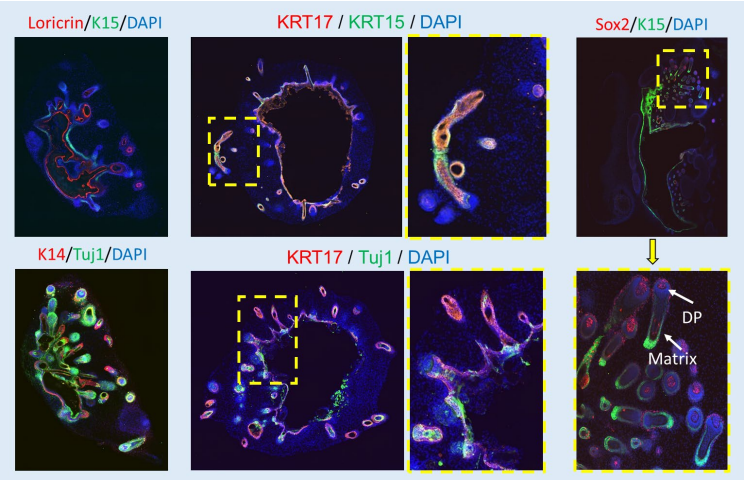


***Figure 4**: Modulation of the transforming growth factor β (TGFβ) and fibroblast growth factor (FGF) signaling pathways leads to the development of hair-bearing skin.*

Conclusions: Fully functional human skin organs with complete appendages were generated from human pluripotent stem cells.

Clinical impact: The human skin organoids generated in the current study could be utilized as an important platform to study human skin development, disease modelling and in reconstructive surgeries.

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0048

6 - 10 September 2021
Education Centre
RBWH

Cutaneous Wound Healing and Skin Reconstruction Using Biofabrication-Based Therapies

Abbas Shafiee [1, 2, 3], Peter Gillies [1, 2], Andrew Dalley [1, 2], Kiarash Khosrotehrani [1, 3], Jason Brown [1, 2]

1- Herston Biofabrication Institute, Metro North Hospital and Health Service, Brisbane, Australia; 2- Royal Brisbane and Women's Hospital, Metro North Hospital and Health Service, Brisbane, Australia; 3- UQ Diamantina Institute, Translational Research Institute, The University of Queensland, Brisbane, Australia.

Purpose: Non healing wounds and skin loss are major healthcare problems around the world costing the healthcare systems billions of dollars a year The Herston Biofabrication Institute (**Burns, Skin & Wounds Program** aims to utilize biofabrication strategies for effective wound healing (**Figure 1**).

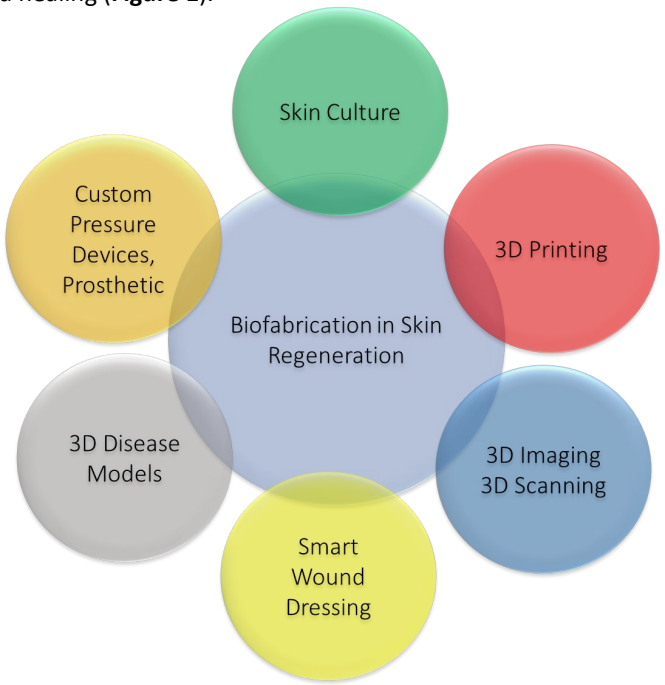


Figure 1 :: Biofabrication techniques in skin regeneration and wound care.

Our approach: The Burns, Skin Wounds Program **is focused** on:

- 3D patient assessment of burn depth and size to guide surgical planning and treatment using advanced 3 D imaging technologies.
- Post operative burn scar management using 3D scanning, 3D modeling, and 3D printing for custom pressure devices and prosthetics (**Figure 2**)
- Optimizing the skin culture techniques, and development of tissue engineered skin as an alternative to the use of donor skin for burns patients (**Figure 3**)

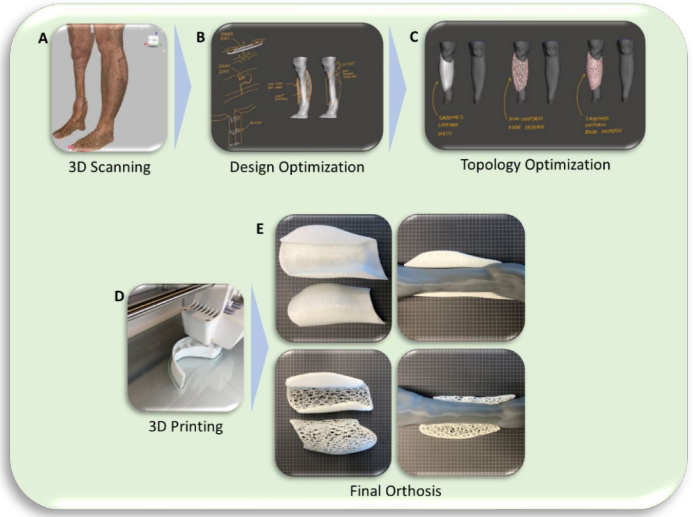


Figure 2: Design and 3D printing of patient specific orthosis for leg burns (Images provided by Mr. Roozbeh Fakhr).

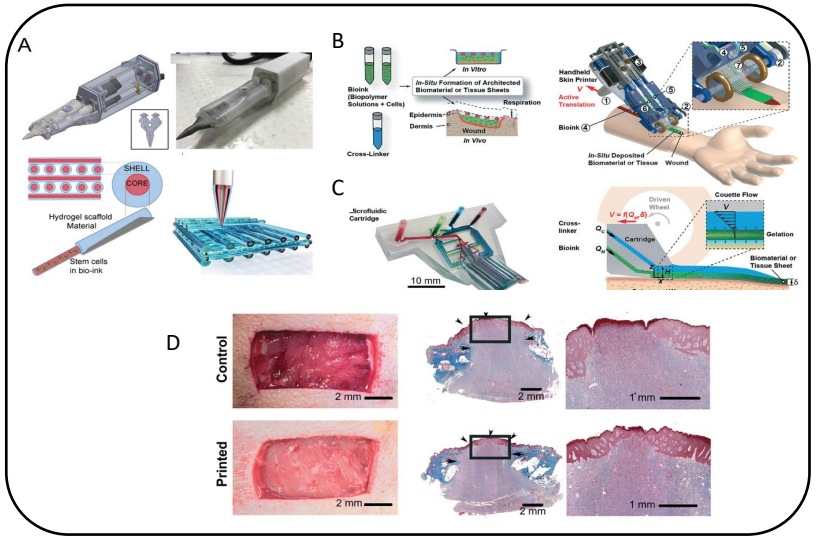


Figure 3: In situ bioprinting of skin cells to generate functional skin layers and accelerate wound healing of full thickness wounds. *Heinrich MA, Small. 2019*.

Conclusions: Conducting translational research through the emerging and state of the art biofabrication technologies allows us to provide the highest clinical benefit in patients These emerging techniques have the immense potential to radically revolutionize therapies for patients with non healing wounds and large skin loss.

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

DISC-0054

6 - 10 September 2021
Education Centre
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Establishment of a Skin Tissue Bank for the Queensland Skin Culture Centre, part of The Professor Stuart Pegg Adult Burns Centre, RBWH.

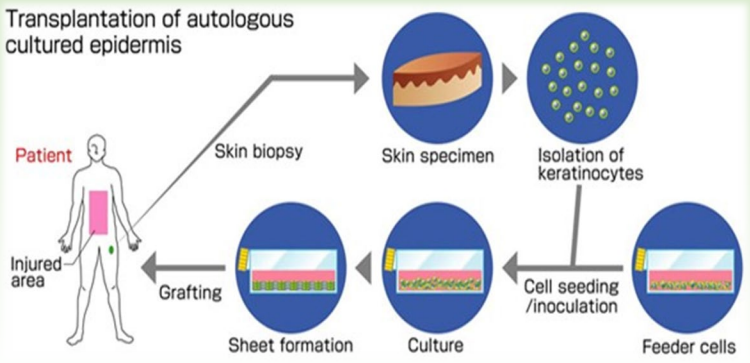
Andrew Dalley[1, 2], Peter Gillies[1,2], Abbas Shafiee[2], Jason Brown[1,2,3]

[1] Queensland Skin Culture Centre (QSCC), [2] Herston Biofabrication Institute (HBI), [3] Professor Stuart Pegg Adult Burns Centre, Royal Brisbane and Women's Hospital, Herston, Brisbane, Australia

Background

The Queensland Skin Culture Centre (**QSCC**) is a purpose built cell culture facility. It is a Royal Brisbane and Women's Hospital initiative that is integral to the **Professor Stuart Pegg Adult Burns Centre** which is the major burns referral centre for Queensland, Northern New South Wales, the Northern Territory and the Pacific Islands.

When called upon, the **QSCC** expands cultures of keratinocytes derived from a patient's skin under precisely controlled conditions to produce Cultured Epithelial Autografts (CEA) that can be safely returned to the patient as part of their wound management plan. Application of CEA sheets to skin graft donor sites greatly reduces the time taken for the donor site to heal and allows skin graft donor sites to be re-harvested more frequently.



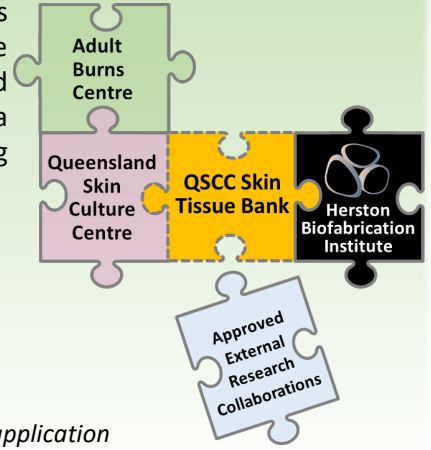
Objective

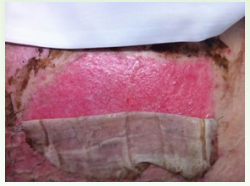
To establish a biobank of de-identified viable cultured skin cells that will promote and support quality research into human skin cell biology and wound healing.

Application

The QSCC Skin Tissue Bank will be the central biological resource for advancing burn wound management practice via numerous projects being pursued by the *Burns, Skin & Wounds Program* at the Herston Biofabrication Institute (**HBI**).

QSCC Skin Tissue Bank resources are also intended to provide Human Research Ethics Approved external research partners with a simplified method for accessing high quality research material.





A skin graft donor site healing after application of a Cultured Epithelial Autograft (CEA)

Methods & Results

In July 2021, Professor Stuart Pegg Adult Burns Centre surgeons commenced prospectively recruiting participants for the newly established QSCC Skin Tissue Bank. To date (mid August 2021), from two participants a total of $300x10^6$ keratinocytes have been banked in 130 cryovials alongside matched DNA & RNA reference material.

Human Research Ethics Considerations

All aspects of the QSCC Skin Tissue Bank activities and subsequent research applications are conducted in accordance with approvals from Human Research Ethics Committees of the Metro North HHS.

Cultured Epithelial Autograft (CEA)

Cryovials of keratinocytes

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

TRAN-0027

6 - 10 September 2021
Education Centre
RBWH

Quality Assurance in Medical 3D-printing: A Dimensional Accuracy Study of Patient-specific 3D-printed Vascular Anatomical Models

Philip Nguyen[1], Ivan Stanislaus[2], Clover McGahon[2], Krishna Pattabathula[3,4], Nigel Pinto[3,4], Jason Jenkins[3,4], Christoph Meinert[4]

[1] School of Medicine, The University of Queensland
[2] Queensland University of Technology
[3] Royal Brisbane and Women's Hospital, Metro North Hospital and Health Services
[4] Herston Biofabrication Institute, RBWH, Metro North Hospital and Health Services

Purpose

3D printing enables the rapid manufacture of patient-specific anatomical models that substantially improve patient consultation and offer unprecedented opportunities for surgical planning and training. Here, we sought to validate the dimensional accuracy of vascular anatomical models manufactured using common 3D printing modalities including Fused-Deposition Modelling (FDM), Stereolithography Apparatus (SLA), Selective Laser Sintering (SLS), and MultiJet (MJ) 3D printing.

Methods

3D models of patient anatomy were produced by segmentation of computed tomography angiography (CTA) scans using Materialise Mimics, followed by the addition of measurement reference points and digital processing in Materialise 3Matic. Models were then manufactured via FDM, SLA, SLS and MJ 3D printing, respectively, using standard settings. The dimensional accuracy of the digital and 3D-printed models was assessed and compared to original CTA data to investigate errors introduced at different steps of the medical 3D printing process.

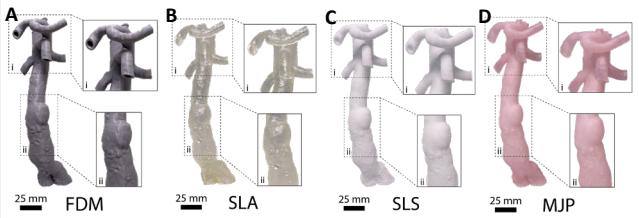


Figure 1 Abdominal aortic aneurysm models representative of each printing modality. A. FDM. B. SLA. C. SLS D. MultiJet

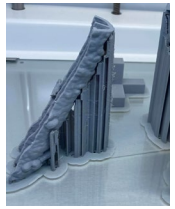


Figure 3 FDM Printed model with support material attached to underside.

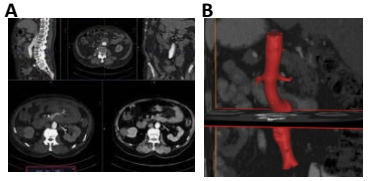


Figure 2
A. Abdominal aorta is imaged via CT angiogram. B. The Aorta (red) has been segmented from the CT image.

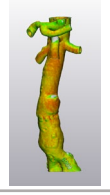


Figure 4 Heat map representation of dimensional accuracy of printed models compared to original CT scans.

Results

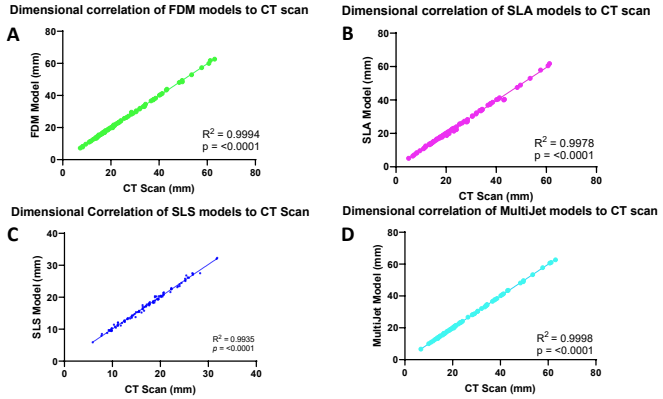


Figure 3 A-D Depict strong correlation between digital models and 3D printed models for all printing modalities with all R^2 >0.99

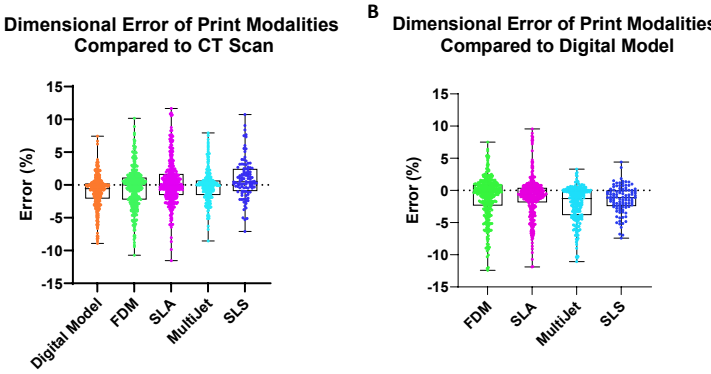


Figure 4 Comparison of the percentage error of each printing modality compared; A. CT scan data and B. as corrected for error occurring during digital processing.

Dimensional Error of Feature Size for all Printing Modalities

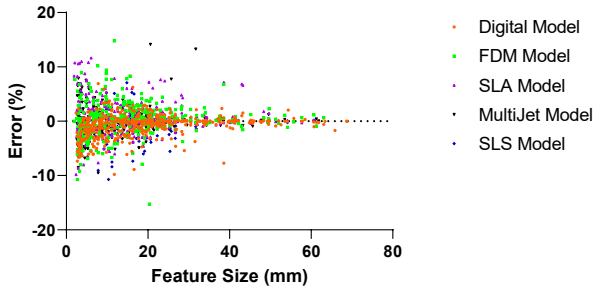


Figure 5 Error of 3D printed models compared to original CT scans depicting increasing error present in all 3D printing modalities as dimension approaches zero.

Quantitative assessment revealed an overall printed model deviation of -0.41 ± 0.71% (MEAN ± STDEV), +0.39 ± 0.58%, +0.88 ± 0.64% and -0.15 ± 0.44% for FDM, SLA, SLS-printed models and MultiJet, respectively, compared to unmodified CTA data.

Comparison of digital 3D models to CTA data revealed a mean error of -0.97% ± 0.08%, resulting from digital anatomical segmentation and processing.

Therefore, deviations resulting from the print modality alone were -0.99 ± 0.71%, +0.99 ± 0.62%, -1.35 ± 0.64% and -2.04 ± 0.46% for FDM, SLA, SLS and MultiJet printed models, respectively.

Conclusions

This study established novel quality assurance procedures and revealed a high level of dimensional accuracy of 3D-printed patient-specific vascular anatomical models, suggesting they meet the requirements for clinical applications.

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

TRAN-0032

6 - 10 September 2021
Education Centre
RBWH

Mapping Osteochondral Injuries of the Talar Dome Associated with Tibial Pilon Fractures

Nicholas Green[1], Gregory Barlow[1], Miran Stubican[1], Frode Vindenes[1], Vaida Glatt[2] Kevin Tetsworth[1], [1]Herston Biofabrication Institute [2]University of Texas

Purpose: The two main mechanisms of injury (MOI) for distal tibial pilon fractures are, falling from a height and motor vehicle accident (MVA). This study investigated concurrent talar dome injuries associated with tibial pilon fractures, mapping their distribution across the dome of the talus while comparing the two main MOI's.

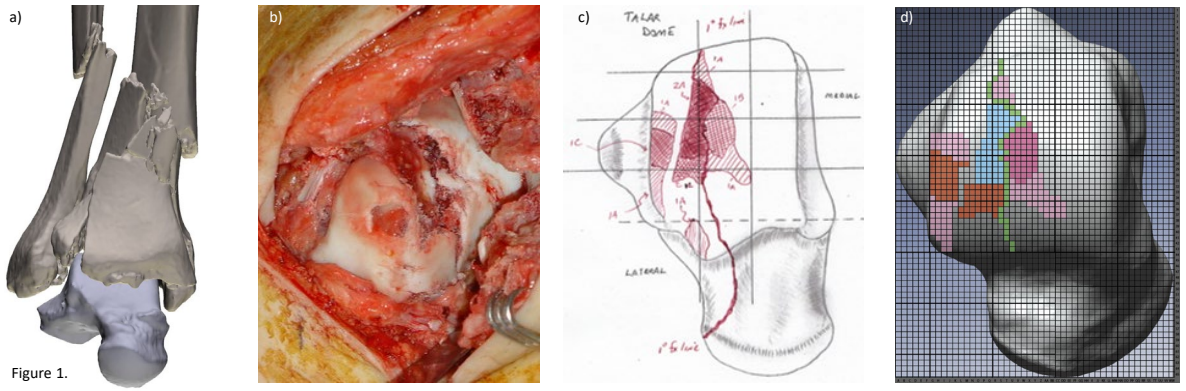
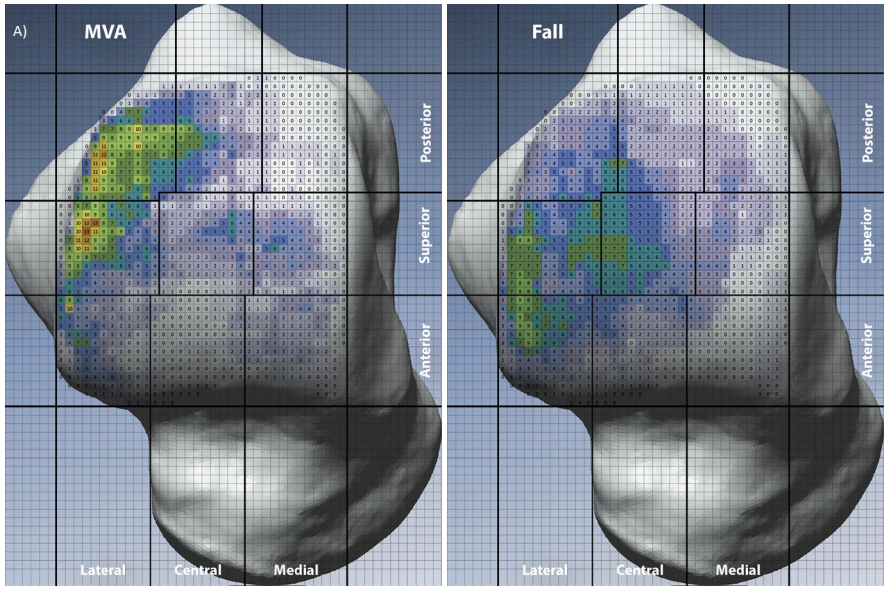


Figure 1.

From left to right: a) a 3D model of a tibial pilon fracture; b) an interoperative photo of a talar fracture; c) map of talar injury drawn by the lead surgeon; d) the digitally transposed injury pattern on a statistical shape model (SSM) of a talar dome.

Methods: From a previously compiled database of acute distal tibial pilon fractures (AO/OTA 43B/C) in adults, 53 cases were identified with a concurrent injury to the talar dome and a known mechanism of injury. Case specific 2D injury maps were grouped by their MOI and then overlayed in an Excel document. Each time an injury was present within a square of the 1x1mm grid overlaying the talar dome, it was tallied and compiled.

Results: Injuries sustained by the talar dome during falls were concentrated in the combined lateral anterior to posterior column (59%) with an 8.3% likelihood that any square on the dome would be injured. MVAs injuries were concentrated in both the lateral anterior to posterior column (50%) and across the superior lateral to medial row (47%) with an 14.2% likelihood that any square on the dome would be injured. A chi square test of independence was performed to determine if there was a significant relationship between MOI and sex. It was found to be significant, with men more likely to injure themselves falling from a height than women X2 (1, N=53) = 5.53, p= .0187.



B) **Mechanism of Injury vs Sex**

	Fall	MVA	Total
Male	29	12	41
Female	4	8	12
Total	33	20	53

C) **Comparison of Injury Grade vs Mechanism of Injury**

Injury Grade	Fall	MVA	Total
Chondral	17	14	31
Osseous	16	6	22
Total	33	20	53

D) **Likelihood of Injury per section - All bones**

	Lateral	Central	Medial	Combined ML
Posterior	19.6%	10.3%	2.1%	32.0%
Superior	22.4%	15.4%	6.1%	43.9%
Anterior	14.7%	5.7%	5.7%	3.8%
Combined AP	56.8%	31.3%	11.9%	100.0%

Figure 2.

From left to right: a) Heatmap representing the injuries sustained to the talar dome in association with distal tibial pilon fractures (AO/OTA 43B/C), comparing injuries from MVA's to falls. B) Presence of injury when a patient presented with a tibial pilon fracture, comparing mechanism of injury versus sex. C) A table of the grade of injury sustained comparing the different mechanisms of injury. D) Cumulative likelihood of injury across all sections.

Conclusions: The MOI has important implications regarding the resulting pathology, requiring further research.

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

TRAN-0035

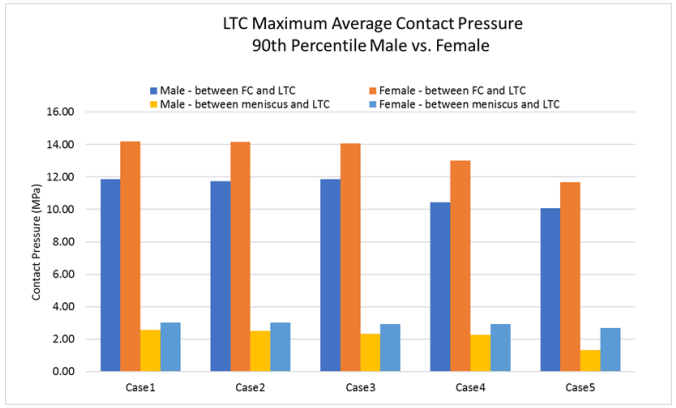
6 - 10 September 2021
Education Centre
RBWH

Increased cartilage pressure exposes female athletes to greater risk of osteoarthritis: A dynamic finite element study

Deniz Erbulut[1] , Nick Green[1], Kevin Tetsworth[1] 1. Herston Biofabrication Institute

Purpose: The focal articular cartilage defect is mainly seen in the knee joint of active athletes and remains a significant clinical problem [1,2]. Mechanical overloading causes considerable damage to the collagen network of articular cartilage. Thus, it is necessary to place a high emphasis on the prevention of articular cartilage defects caused mostly by sports activities, as cartilage defects can eventually progress to osteoarthritis (OA). The magnitude of tibial cartilage contact pressure developed in the knee joint during sports activities under subfailure ACL injury loading is currently unknown. We hypothesized that landing during sport activities, implication for subfailure ACL loading, would generate greater contact pressures (CP) at the lateral knee compartment. The objective of this study was to analyze tibiofemoral articular cartilage contact pressure magnitudes in females and males, under clinically relevant noncontact ACL subfailure loadings including knee abduction moment, internal tibial torque, anterior tibial shear forces, and impact during landing.

Methods: Tibiofemoral cartilage contact pressures (TCCP) under clinically relevant anterior cruciate ligament subfailure external loadings were predicted using four dynamic explicit finite element (FE) models (2 males and 2 females) of the knee. Bipedal landing from a jump for five cases of varying magnitudes of external loadings (knee abduction moment, internal tibial torque, and anterior tibial shear) followed by an impact load were simulated. The models were validated against an in vitro study which was conducted by Bates et al. [19]. Impact value of 4158 N which is equivalent of the drop load of half a body weight (bipedal landing) from 30 cm were used. The loadings included knee abduction moment (KAM), anterior tibial shear force (ATS), and internal tibial rotation moment (ITR) and were matched to the corresponding in vivo kinetic measurements previously undertaken.



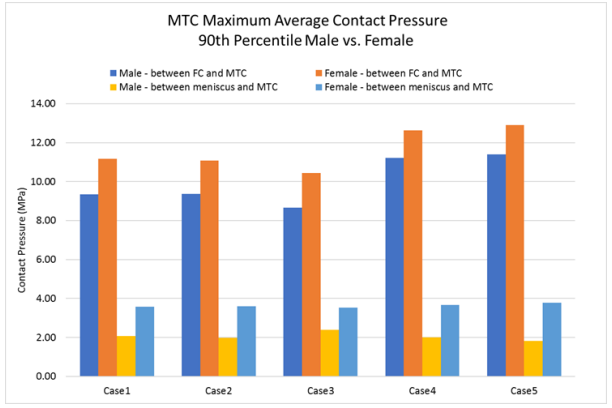


Figure 2: The maximum of average contact pressures (total contact force / total contact area) in lateral compartment for 90th percentile male and female models for Cases 1-5

Results: Lateral TCCP from meniscus (area under meniscus) and from femur (area under femur) increased by up to 94% and %30 respectively when external loads were incorporated with impact load in all the models compared to impact-only case. In addition, FE model predicted higher CP in lateral compartment by up to 37% (11.87 MPa versus 8.67 MPa) and 52% (20.19 MPa versus 13.29 MPa) for 90% and 50% percentile models, respectively. For the same percentile populations, CPs were higher by up to 25% and 82% in smaller size models than larger size.

Conclusions We showed that subfailure ACL loadings obtained from previously conducted in vivo study led to high pressures on the tibiofemoral cartilage. This knowledge is helpful in enhancing neuromuscular training for athletes to prevent cartilage damage. We can conclude that the decrease in abduction moment, which would be possible with neuromuscular training, may reduce the risk of excessive lateral compartment contact pressure and associated articular cartilage injury during sports activities.

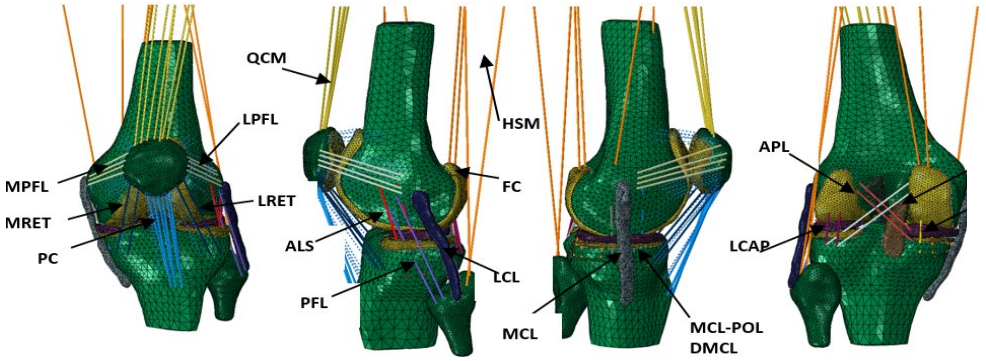
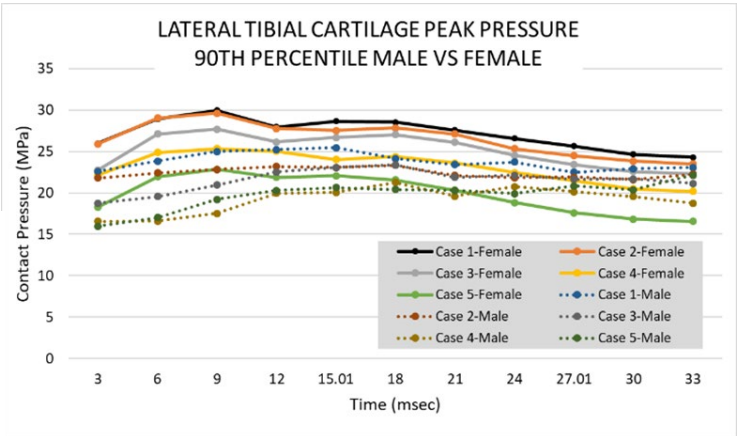


Figure 1: FE models with all the components



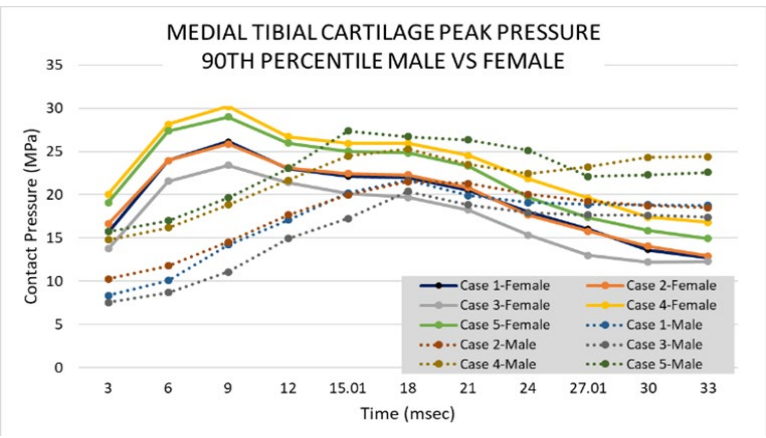


Figure 3: Peak contact pressures for 90th percentile male and female models within the first 33ms after impact for Cases 1-5 (A) Tibial lateral compartment (B) Tibial MC

Scaffold – Fluid Flow (Semi-Closed)

Scaffold – 53.5% porosity, 25mm scaffold size (Scaled) (Open structure)

Healthcare Innovations
How practice has changed

HERSTON HEALTH PRECINCT SYMPOSIUM 2021

TRAN-0037

6 - 10 September 2021
Education Centre
RBWH

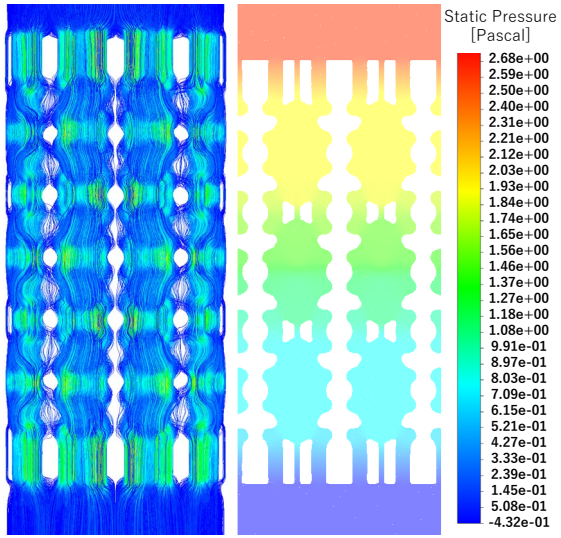
Morphological Orthopaedic Scaffolds could be plug 'n' print?

Lut In Tam[1], Aravind Payyapatt[1], Nick Green[2], David Forrestal[2], Kevin Tetsworth[2], Deniz Erbulut[2]
1. The University of Queensland 2. Herston Biofabrication Institute

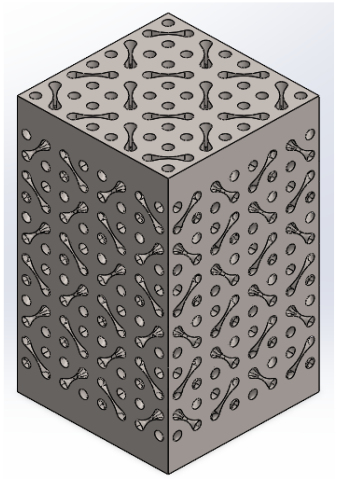
Purpose: Biocompatibility and customisation are key components in orthopaedic implants. Employing additive manufacturing (AM), titanium based porous scaffolds can be developed using unit cell (UC) structures with customisable pore size and properties that can be optimised for specific clinical applications. A key feature of biocompatibility is Fluid-flow dynamics within the porous structure as it is closely related to the supply of nutrients essential for cell activity. In this study, the scaffolds were assessed for permeability to improve the biological performance and bone in-growth by encouraging nutrient flow to cells.

Methods: A porous UC was developed based on a novel design proposed by a medical professional using computer aided design (CAD). Orthopaedic scaffolds with open structures were generated from this UC and scaled to size. Preliminary testing was undertaken on scaffolds (titanium alloy) for Force-Displacement relationship at varying scaffold porosities (approx. 50, 70 and 90%) using Finite-element analysis (FEA). Fluid flow was also tested at specific levels of porosity and pore diameter using Computational fluid dynamics (CFD). Data from CFD analysis was then used to optimize the design of scaffold structure by adjusting parameters such as pore diameter, channel width and internal surface smoothing to improve CFD simulations until satisfactory results were achieved.

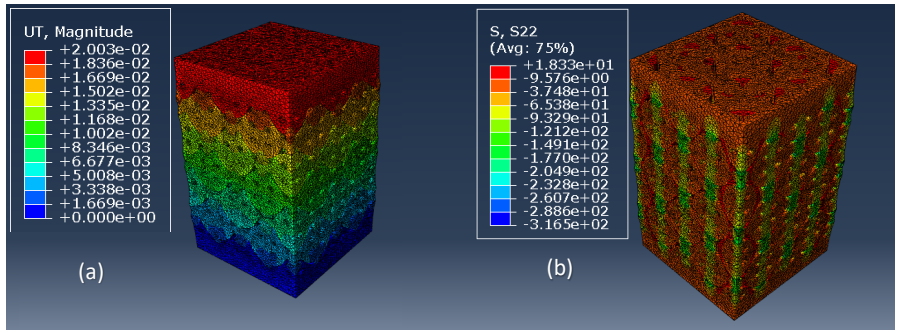
Results: Current UC design (semi-closed structure) with cell size 10 mm, pore diameter 2.5 mm and a 50.3% porosity gives a permeability of 3.73×10^{-8} m^2. FEA for Scaffolds (Open Structure) at 107 GPa (Titanium alloy) was tested under compression for varying porosities as shown below. For 53.5% porosity, 11.97 kN of force was required for a displacement of 0.1 mm. This data was compared to mechanical testing data yielding average error of 12.68% (from all displacements for 53.5% porosity).



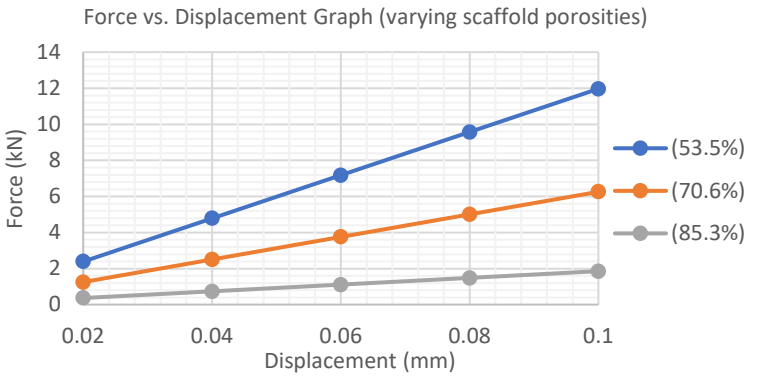
Scaffold – Fluid Flow (Semi-Closed)



Scaffold – 53.5% porosity, 25mm scaffold size (Scaled) (Open structure)



53.5% porosity scaffold a) Displacement b) Stress distribution



	Force (kN)		
Displacement (mm)	**53.50%**	**70.60%**	**85.30%**
0.02	2.394	1.253	0.371
0.04	4.789	2.506	0.742
0.06	7.183	3.759	1.113
0.08	9.577	5.011	1.484
0.1	11.97	6.264	1.855

Conclusions: Human trabecular bone permeability was found to be 5.13 x 10-9 m2, which is a lot smaller than the designed scaffold permeability which has permeability of 3.74 x 10-8 m2. Even the result in CFD is significantly larger, the rough surface in the actual printed scaffold contributed a lot to fluidic performance. For further investigation, a micro-CT scan of the printed scaffold can be computationally simulated in order to achieve a more accurate result. FEA testing has provided preliminary data that describes the rate of displacement, but more data is required at higher displacements to predict behaviour more accurately. This will then be provided for CFD analysis until the scaffold design is optimised and ready for implementation as orthopaedic implants.