Form follows function: design, development and application of a new tool to assess how the 3D microstructure of biological tissues changes during mechanical loading

A Data Management Plan created using DMPonline.be

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Project abstract:

Biological tissues undergo physiological mechanical loading during their functioning in vivo. To properly respond to these mechanical signals, tissues have a highly complex microstructural organization. However, there is not yet sufficient knowledge about the link between their microstructural organization and their mechanical behaviour. Therefore, this PhD project aims to optimize a novel tool that allows to dynamically assess in 3D how the microstructure of unmineralized tissues changes during mechanical loading, namely 4D-CECT. As only limited research has been done using this technique, the goal is to improve its overall performance. To do so, the first objective is to improve the current loading stages by incorporating temperature and humidity control. We will also extend the stages to more complex loading modes, since biological tissues are in vivo not just imposed to simple uniaxial forces. The second objective is to optimize the image acquisition and reconstruction, and this to avoid tissue damage as well as to obtain sufficient image quality to be able to determine the microstructural changes during loading and to obtain accurate quantitative data on the local strain distribution. For this project, healthy vascular tissues and cartilage will be used; two unmineralized tissues, but strongly different in their structure and function. Finally, our novel and optimized technique will be applied to try to better understand how diseases alter tissues mechanical behaviour.

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1. Research Data Summary

List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data.

				Only for digital data	Only for digital data	Only for digital data	Only for physical data
Dataset Name	Description	New or reused	Digital or Physical	Digital Data Type	Digital Data format	Digital data volume (MB/GB/TB)	Physical volume
		Please choose from the following options: • Generate new data • Reuse existing data	*Please choose from the following options:* • Digital • Physical	*Please choose from the following options:* • Observational • Experimental • Compiled/aggregated data • Simulation data • Software • Other • NA	*Please choose from the following options:* • .por, .xml, .tab, .cvs,.pdf, .txt, .rtf, .dwg, .gml, … • NA	*Please choose from the following options:* • <100MB • <1GB • <100GB • <1TB • <5TB • <10TB • <50TB • >50TB • NA	
1. Data from imaging experiments							
Dataset 1.1 - Tissue samples	animal arteries(porcine, rat,mice, sheep).Animal arteries come from the slaughterhouse	Generated new Data	Physical sample				Not stored after used
Dataset 1.2 - Synthetic graft samples	Vascular synthtic grafts	Generated new Data	Physical samples				Not stored after used
Dataset 1.3 - Imaging Data	Grey-scale images from the Nanotom M uCT. RGB images from 2D classical histology	Generate new data	Digital	Experimental, Images	.bmp, .tiff, .jpg	<50TB	
Dataset 1.4 - Protocol (image analysis & sample preparation)	Protocols on how to prepare sample, postprocess and analyze the images.	Generate new data	Digital	Observational, Simulation data	.txt,.csv,.pdf,.xlsx, .docx,	<1GB	
2. Ex-situ Experimental mechanical characterisation							
Dataset 2.1 - Mechanical data	Raw data of the mechanical tests	Generate new data	Digital	Experimental	.mat, .csv, .text	<1TB	
Dataset 2.2 - Parameter fitting code	Matlab or Python code that has as input the raw data of the mechanical experiments	Generate new data	Digital	Software (Matlab, Python)	.mat,.dat, .py,.ipynb	<1GB	
3. Prototyping in-situ mechanical stage							
Dataset 3.1 - Drawings	Drawings of parts constituting the final prototype	Generate new data	Digital	Software (Solidworks)	.sldprt, .sldasm, .stl, .slddrw	<1TB	

If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type:

Dataset 1.3 & 1.4 - imaging data and protocols:
Dataset from my ContrasTTeam research group not published yet
Maes, A., Pestiaux, C., Marino, A. et al. Cryogenic contrast-enhanced microCT enables nondestructive 3D quantitative histopathology of soft biological tissues. Nat Commun 13, 6207 (2022). https://doi.org/10.1038/s41467-022-34048-4 (https://doi.org/10.1038/s41467-022-34048-4)
Lisa Leyssens et al., Non-destructive 3D characterization of the blood vessel wall microstructure in different species and blood vessel types using contrast-enhanced microCT and comparison with synthetic vascular grafts., Acta Biomateriala, soon to be published

Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? Describe these issues in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Will you process personal data? If so, briefly describe the kind of personal data you will use in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Does your work have potential for commercial valorization (e.g. tech transfer, for example spin-offs, commercial exploitation, ...)? If so, please comment per dataset or data type where appropriate.

- Yes

If applicable, IP protection will be investigated in collaboration with the KU Leuven/UCLouvain LRD office.

Do existing 3rd party agreements restrict exploitation or dissemination of the data you (re)use (e.g. Material/Data transfer agreements/ research collaboration agreements)? If so, please explain in the comment section to what data they relate and what restrictions are in place.

- No

Are there any other legal issues, such as intellectual property rights and ownership, to be managed related to the data you (re)use? If so, please explain in the comment section to what data they relate and which restrictions will be asserted.

- No

2. Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep data understandable and usable, for yourself and others, now and in the future (e.g., in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, Codebook.tsv etc. where this information is recorded).

1. Data from imaging and mechanical experiments
The documentation of the experiments consists of:
Test protocols: SOPs and specific protocols of the performed mechanical test
Manuals: manuals for operating the testing devices, performing the scans, etc
Elabjournal containing all the imaging parameters selected and pictures of experiments
2. Data from prototype design
All CAD parts are accompagnied with CAD drawings and is accompagnied with a .docx descriptive file of the prototype assembly.
3. General computing code
All generated processing and analysis code is accompanied with a readme-file and contains a header to describe its content, author(s) and last modification date.

Will a metadata standard be used to make it easier to find and reuse the data? If so, please specify (where appropriate per dataset or data type) which metadata standard will be used. If not, please specify (where appropriate per dataset or data type) which metadata will be created to make the data easier to find and reuse.

- No

3. Data storage & back-up during the research project

Where will the data be stored?

Apart from non-sensitive raw images, data will be stored on facilities of the research unit or university. This includes:
- Storage for archiving of non-sensitive raw images.
- Git repository for code development.
- OneDrive for office files.
- UCLouvain shared drives and personal drive for office files.
- Large Volume Storage (LVS) for storing imaging datasets backed-up by UCLouvain.
- Elabjournal containing all the experimental protocols.

How will the data be backed up?

All data are stored on the university's central servers (LVS by UCLouvain) with automatic daily back-up procedures. If not located in one of the above drives, all research-related documents are to be stored in a folder on the researcher's pc that is synced with OneDrive for Business cloud storage

Is there currently sufficient storage & backup capacity during the project? If yes, specify concisely.
If no or insufficient storage or backup capacities are available, then explain how this will be taken care of.

- Yes

How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?

All data is securely stored on UCLouvain servers and only accessible by members of the research unit through authentification

What are the expected costs for data storage and backup during the research project? How will these costs be covered?

The promoter and co-promoter will take care of the costs for storage on ongoing project grants. UCLouvain charges a fixed price per TB for the LVS storage (150€/TB per year).

4. Data preservation after the end of the research project

Which data will be retained for at least five years (or longer, in agreement with other retention policies that are applicable) after the end of the project? In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies...).

All datasets will be retained for 5 years after the end of the project (and for publications, until 5 years after the work has been published). Biological samples are destroyed after mechanical testing and can in any case not be retained due to preservation issues. However, the animal samples will be discarded once a paper is published on the topic.

Where will these data be archived (stored and curated for the long-term)?

All the imaging datasets used for publications will be archived for 5 years in LVS from UCLouvain.

What are the expected costs for data preservation during the expected retention period? How will these costs be covered?

The costs will not exceed €5000 and will be covered by the budget of the supervisor.

5. Data sharing and reuse

Will the data (or part of the data) be made available for reuse after/during the project? In the comment section please explain per dataset or data type which data will be made available.

- Yes, in a restricted access repository (after approval, institutional access only, …)
- Other, please specify:

For each outcome of the PhD project (imaging datasets, new techniques, etc), IP rights will be ad hoc discussed with the partners involved in the project. Trade off between patenting and open access will be considered. Once IP is protected, the outcome will be made available via Open Access repositories or upon request after publication. Especially for the imaging datasets, which are very large (>50GB/dataset), the data will be made available upon request and can be send via BelNet Filesender. For the biological samples, they will not be available for reuse or shared. For the mechanical data, they will be made available within UCLouvain LVS upon request, via scientific papers and 'data papers' if supported by the journals, via data repositories, such as for example Zenodo, or other repositories upon request, etc.

If access is restricted, please specify who will be able to access the data and under what conditions.

The restriction of the imaging datasets comes mainly due to the large size of the datasets, and the related cost for long term storage in open access repositories. Therefore, the datasets will be made available upon request, and can be send via BelNet FileSender. Once IP is secured and once the related results, datasets are published, everyone should be able to obtain access to the imaging datasets upon request. For the smaller datasets (i.e. protocols, mechanical data), once published, the datasets should be accessible via open access repositery.
Members of the research unit will be able to access the data via the shared drives.
The scientific community will have access to the data under the following conditions of use: CC BY, in which appropriate credit must be given to the author and indication of changes must be made, and CC BY-NC, which adds a non-commercial term to the CC BY license.

Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)? Please explain in the comment section per dataset or data type where appropriate.

- Yes, Other

My PhD is a joint-PhD between the university of KU Leuven and UCLouvain. Therefore, a joint-PhD agreement has been signed, which states that the property, publication, use and protection of the results of the research is common to the two host institutions and are required to be in conformity both with the specific procedures in each of the two communities as well as the relevant internal regulations of each institution. Any cases of potential conflict in the provisions will form the subject of arbitration between the KU Leuven and the UCLouvain. This can restrict or prevent the sharing of my data. Furthermore, the large size of the imaging datasets and the cost related to long term storage in open access repositories, can also be a restriction to sharing in open access such datasets. In this case, the imaging datasets will be made available upon request.

Where will the data be made available? If already known, please provide a repository per dataset or data type.

For the publications, it will made available on DIAL and LIRIAS, the universities repositories for papers and conference abstracts. For the datasets smaller than 50GB, it can be made available on zenodo (https://zenodo.org/) and can be linked to the ORCID number and the DOI.

When will the data be made available?

When IP is secured for both universities (UCLouvain, KU Leuven) and upon publications of the results, then the data will be made available.

Which data usage licenses are you going to provide? If none, please explain why.

Providing usage licences or not will be ad hoc discussed for each type of datasets with the partners involved in the project.

Do you intend to add a PID/DOI/accession number to your dataset(s)? If already available, you have the option to provide it in the comment section.

- No

What are the expected costs for data sharing? How will these costs be covered?

Our large datasets are stored on LVS where university members can have access to the data upon request. The cost is about 150€ per TB per year. This is for storage, but we can give access to the datasets upon request. Cost will be covered on other grants than the FWO mandate budget (bench fee), from the both promoters.

6. Responsibilities

Who will manage data documentation and metadata during the research project?

The PhD researcher is responsible for data documentation and metadata.

Who will manage data storage and backup during the research project?

The PhD researcher is responsible for data storage and back up during the project.

Who will manage data preservation and sharing?

The PhD researcher is responsible for ensuring data preservation and sharing via the shared storage drive during the PhD project. After the PhD project, the supervisor will be in charge of this.

Who will update and implement this DMP?

The PhD researcher is responsible for updating & implementing this DMP during the project. After the PhD project, the supervisor will bear the end responsibility of updating & implementing this DMP.