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The ethics of 3D printing copies of bodies donated for medical education and research: What is there to worry about?

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EDITORIAL

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Many emerging technologies have the potential to revolutionise aspects of everyday life. At every turn, new examples of technological advances surround us, from self-driving cars through to gene therapy and genomic medicine. The rapid development and integration of 3D printing is another example of a new technology having a major impact on society. Objects can now be printed as near-perfect reproductions by anyone with a moderately capable computer and enough money to purchase a 3D printer. Everyday items, furniture, household appliances, and even guns can now be reproduced. Even human body parts, from cadavers donated to medical science, are now being 3D printed and used for the purpose of medical education and research.[1]

Technology is advancing rapidly across many fields and with each discovery potentially comes new problems and questions that have not yet been asked, let alone answered. Genomic medicine, with all its potential and ability to help cure serious diseases, has many social, legal, and ethical issues that have not been resolved,[2] yet the science behind the topic continues to advance despite this fact. Three-dimensional printing of bodies donated to medical science, with the subject matter of body donation surrounded by issues of cultural sensitivity, ethical practice, and legal obligation, also brings with it new ethical questions that require consideration by the wider anatomy community. It is therefore necessary that ethical issues that may encompass the implementation and use of 3D printing are explored to help guide the responsible integration of this new technology into the anatomical and medical sciences. In this way, the trust and relationship between the donors, anatomy schools, and the public will be maintained and a robust platform developed that allows the precious resource of donated bodies to be used ethically and responsibly.

The integration of 3D printing into anatomical science is a wonderful application of a new technology.[2] It means that body parts from donated cadavers can be cheaply replicated to provide a resource for anatomy education. The benefits of this are widespread: anatomy schools in poor areas can now acquire resources cheaply; schools without body donor programmes can access teaching resources; and bodies found to have a novel anatomical variation can be copied and stored for future use or comparison with “normal” anatomy. Three-dimensional copies of body parts, while not providing as much anatomical detail as “real” body parts, provide enough detail for use as an educational and research resource. The benefits of this technology are similar to those of plastination, a technique whereby human tissue is preserved using a plastic polymer to produce a flexible and robust anatomical specimen.[3] However, 3D printed body parts are likely to be managed differently (and perhaps more easily) than plastinated specimens as issues around the storage and use of “actual” human tissue do not need such close scrutiny or attention. They are also likely easy to store, do not require special laboratories, and are cheaper to produce than plastinated material.[1]

There are physical similarities between plastinates and 3D models rendered from donated body parts. Both involve the production of a physical resource that originated from a donated body; they can both be stored and used (potentially) ad infinitum. So what about potential parallels in regard to ethical issues affecting the use of both? Clearly, there could be the potential to use such

items as "art" as von Hagens has done with plastination,[4] though that should perhaps be considered separately from use in education and research. There is currently little information available on the ethical issues of 3D printing of body parts for use in anatomy education and research.

In commenting on the ethical issues of 3D printing of body parts, McMenamin et al. suggest that in Australia, local government authorities "see no ethical dilemma" in the reproduction of body parts using 3D printing, drawing a parallel with 2D images that are gathered for textbook and multimedia use.[1] Such a statement is interesting, as ethical issues involving the acquisition and use of images arising from donated cadavers are now being considered given there is no empirical evidence to guide current practice on this topic.[5] In some cases, medical schools are requiring separate consent for the acquisition of images from donated bodies in an effort to provide the option of informed choice for potential donors (Claire Smith, Brighton and Sussex Medical School, UK, oral communication, August 2014). The position of informed consent surrounding images acquired from donated bodies is one that is beginning to become more widely discussed within the anatomical sciences,[5] and any consensus on governance in this area may be useful as a guide for how to approach the issue of 3D copies arising from donated body parts given there are some commonalities between the two topics.

State and national law in Australasia, and in many other countries and regions, have existing legislation (to paraphrase) that commercial gain by those parties legally receiving donated bodies is not allowed. The interpretation of the law (e.g., New Zealand Human Tissue Act 2008) is likely an effort to ensure that body parts will not be sold; however, what has not been tested is whether this extends to resources that arise as a result of the use of donated bodies. For example, images arising from donated cadavers may be used in commercial education products that are sold and marketed globally, either in print or via digital resources. The same point of view could be considered for 3D printed body parts, if these were to become commercially available. To test the law and provide some clarity on this issue, the question should be asked: does the generation of resources using reproduction of part(s) of a donated cadaver for profit equal commercial gain, and should it therefore be seen as illegal?

Regardless of whether a legal argument can be supported for the sale of 3D printed body parts being against the law, consideration should be given to the special position that donated bodies occupy in donation programmes and guide the placement of our moral position on the issue. Champney, on the subject of commercialisation of bodies donated to medical science, writes:

> *Human tissues, donated bodies specifically, have value and deserve special treatment. They are not merely property to be bought and sold. They deserve the respect and dignity we would afford any of our deceased loved ones. They should not be 'parted out' and sold like disposable property.*[6]

This highlights not only the sensitive nature of the subject of body donation, but also that commercialisation in any form needs to be scrutinised when bodies donated to medical science are involved. This allows the relationship between the donors, their families, and the recipient schools of anatomy to be protected, supported, and facilitated.

Not only does the commercial distribution of 3D printed body parts require scrutiny, it is also relevant to consider how physical distribution of reproductions may proceed given 3D printed body parts are likely considered "less lifelike" than either dissected human material or plastinated specimens. Real and human-derived (e.g., plastinated) body parts, once the exclusive domain of anatomy schools, could foreseeably appear in schools in front of young children simply because their ease of use and acquisition may provide an avenue for their integration into these educational scenarios. The question could well be asked: how would or should such specimens be viewed when realistic plastic models can be purchased for a similar use? Perhaps the answer lies in reflecting on the origin of the models, as Champney suggests,[6] and in considering what sort of governance of 3D printed body parts is necessary given such items may well be classed as property (taking into account an important legal issue; bodies are not considered property in New Zealand, by law), but that they are also an elegant reproduction of human anatomy rendered from an actual, altruistic person.

Very little is currently known about what would or would not be acceptable to body donors in regard to 3D printing of donated bodies or body parts, even if the acquisition of the body and subsequent print be technically "legal". In this regard, the issues faced by the anatomy profession are very similar to those that accompany the use of images acquired from donated bodies. If permission for 3D printing of a body were acquired, what other information should be provided to the donor to ensure

he/she were fully informed about future use? For instance, how widely could the resulting copies be distributed? Who the donor considers the appropriate end-user for using 3D printed copies is also an issue that has not yet been examined - just the university where the donation took place, or other universities as well? Could universities overseas have access to 3D copies of body parts, or just those that are located locally? Would it be allowable for copies to be sold, and to whom? Where would any profits go? Could high schools access copies for educational purposes, and in what circumstances? Would it be acceptable to upload the digital data to the internet, and allow anyone to download the information and make copies? All these questions are relevant, and rely on input and guidance from the donor population to ensure responsible and acceptable practices are developed to guide the integration of 3D printing technology into anatomical education and research. Answers to such issues would help facilitate responsible use of a precious resource that relies on sensible and sensitive governance to prevent any potential for exploitation.

Discussion of how the use of 3D printing from donated cadavers can be sensitively integrated into anatomy education is urgently required, so that "good practice" can be developed to enable respectful use of this resource that encompasses standards reflecting good social, cultural, and ethical values. The guidelines[7] from the International Federation of Associations of Anatomists (the world governing body of anatomy) state: "There should be no commercialisation in relation to bequests of human remains for anatomical education and research." The guidelines go on to state that this applies not only to the tissue donated, but also the use the body or body part is put towards. At present, what may be occurring with 3D printing of donated bodies without donor permission may constitute lack of "reasonable" informed consent, which is dubious from an ethical viewpoint. At worst, if such printed models are on-sold for profit there is the potential for this practice to be interpreted as illegal and outside the current recommendations of the group that guides the ethical position(s) of anatomical practices.

Examination and discussion around the issue of what may be deemed "responsible and ethical practice" will ensure that the benefits of body donation programmes are maintained while protecting those individuals who so selflessly donate their bodies to medical science. In line with this, perhaps a sensible default position should include the acquisition of informed consent in current donor forms if there is the possibility that the body may be copied using 3D printing, until evidence emerges to support a different position. That may include a general consensus as to when and how an item becomes "not" human, or perhaps delineates when informed consent becomes unnecessary.

Perhaps at the very least, the point of view and permission of the donor should be sought when any new technology is employed for such purpose, given the necessity and obligation for informed consent in the practice of body donation. The concern is that without information or guidance from the donor public any controversy involving new technologies and body donation may adversely affect the sustainability of donor programmes.

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CONFLICTS OF INTEREST

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