



Bioprinting and Transplantation: A Pilot Qualitative Survey of Knowledge, Perceptions and Hopes of Patients and Donors

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Abstract

A shift is taking place in the field of regenerative medicine and transplantation. Recent advances in bioprinting have made available new products, like bio-artificial tissues and organs, that offer to the recipients personalized solutions, reducing surgery duration and fostering tissue regeneration.

Though encouraging, these implants raise critical ethical issues that need to be considered carefully. The existing literature identifies critical ethical, legal and social issues such as the body digitalization, rejuvenation, immortal life, ownership of artificial bioconstructs, intellectual property rights and social discriminations.

However, few publications analyse the ethical problems of early-phase clinical trials and even less articles explore the opinions and the feelings of the stakeholders about the fabrication of bio-artificial organs and their transplantation.

In light of this scenario, this research aims to explore the knowledge, opinions, attitudes and hopes of patients and donors towards the bioprinting and organ transplantation by eliciting the underlying ethical feeling. The findings of this study may help to revise the current ethical, legal and social issues related to regenerative surgery based on a bottom up approach by engaging patients and donors. Moreover, it may contribute to develop or review guidelines dedicated to bioprinting and regenerative transplantation.

Keywords: Bioprinting; Regenerative Transplantations; Bioethics; Patient-Centered Approach; Pilot Study; Qualitative Survey

Introduction

A shift is taking place in the field of regenerative medicine and transplantation [1]. For decades inert implants, like metal or plastic structures, were used to treat a number of conditions. Recently the advances in bioprinting have made available new products [2,3], like bio-artificial tissues and organs, that offer to the patients personalized solutions, reducing surgery duration and ensuring mechanical stability, fostering tissue regeneration, preventing shrinkage and allowing the use of multiple materials simultaneously [1].

Though encouraging, these implants raise critical ethical issues that need to be considered carefully in order to guarantee to the patients the adequate measures of safety and the respect of their rights.

The existing literature identifies thoughtful ethical, legal and social issues associated with the bioprinting of tissues and organs that refer to the body digitalization, the rejuvenation, the immortal life, the ownership of artificial bioconstructs, the intellectual property rights and the social discriminations [4-6].

However, few publications analyse the ethical problems of early-phase clinical trials and even less articles explore the opinions and the feelings of the stakeholders about the fabrication of bio-artificial organs and their transplantation.

Some studies consider the opinions of physicians about the feasibility of using 3D printing technology for organ transplant [7]. Others analyse the perspectives of engineers about the ethical issues raised from the regenerative medicine [8]. Some research, lastly, explore challenges facing the bioprinting industry. Few studies consider the opinions and perspectives of the patients about 3D bioprinted organs [9] and/or regenerative surgery [10].

In light of this scenario, this research aims to explore the knowledge, opinions, attitudes and hopes of patients and donors towards the bioprinting and organ transplantation by eliciting the underlying ethical feeling. The findings of this study may help to revise the current ethical, legal and social issues related to regenerative surgery based on a bottom up approach by engaging patients and donors. Moreover, it may contribute to develop or review guidelines dedicated to bioprinting and regenerative transplantation.

Materials and Methods

Piloting method

Considering the few publications about the patients and donors perspectives on regenerative surgery, a pilot method was chosen to perform this study. Piloting methodology seemed adequate to refine strategies before conducting eventual major research on the same topic [11].

Qualitative analysis

Qualitative interviews were developed to gather data, favored for examining complex and sensitive themes like opinions and/or feelings of participants towards regenerative implants.

A qualitative method enables the collection of in-depth opinions and feelings that quantitative studies may miss. Moreover, it allow researchers to explore research questions and concepts in rich detail [12,13].

Semi structured interviews were chosen for flexibility in the responses and questions, while still covering the core themes.

Written questions were preferred to oral interviews because they allow more thoughtful responses, reduce interviewer bias, ease logistic (cost/distance control) and offer more comfort to participants.

Interview structure

A questionnaire draft was organized according to six sessions: session one asked questions about the social and demographic information of participants. Session two collected data on participant health conditions. Session three explored the knowledge of participants about the bioprinted organs and their use for transplantation. Session four analysed the opinions of participants about bio-artificial organs/tissues and their implant. Final sessions (namely, five and six) investigated the most sensitive dimensions of the feelings of participants such as attitudes, expectations and hopes about the organs bioprinting and their use for transplantation.

Specific questions on the ethical issues related to bioprinting and transplantation were not included in the questionnaire because this study aimed to elicit the eventual ethical knowledge and understanding of the stakeholders through a series of carefully crafted questions. Accordingly, it searched to assist the patients and donors in the 'birth' of their own ideas and understanding about the ethical problems of bioprinting and transplantation of artificial organs.

The questionnaire form was accompanied by a concise sheet giving information about the goal of the survey and the anonymity of the collected data. On the bottom of the sheet date and consent of participants were reported.

The questionnaire draft was written by the researcher conducting this study (ES). Then, the form was sent by e-mail to an expert in the field of Haematology and regenerative medicine for its revision [14]. The returned questionnaire (Table 1) recommended some editing advices (namely, using shorter sentences or simpler words). After corrections, it was sent via e-mail to the secretary of Adoces (AVB) for its distribution to participants. Adoces is a non profit organization established on national level and supporting patients with haematological diseases. The contact with this organization was taken by the researcher during a conference hosted by this association in September 2025 [15].

Session One - Demographic and social data			
N	Theme/question	Open ended answer	Notes
1	Identify your gender: are you male or female?		
2	How old are you?		
3	Level of education		
4	What is your job?		
5	Where do you live?		
6	Do you have a family (e.g., childre, relative)?		
Session Two - Health data			
7	How do you describe your health conditions (healthy, sick, other)?		
8	Which surgery or other medical treatment did you undergo?		
Session Three - Knowledge of organ bioprinting and transplantation			
9	What do you know about the organ bioprinting and transplantation?		
10	What do you associate the world "bioprinting" with?		
11	In which other contexts have you ever heard about bioprinting?		
Session Four - Opinions about organ bioprinting and transplantation			
12	What do you think about the organ bioprinting and transplantation?		
13	Which risks do you see about organ bioprinting and transplantation?		
14	Which benefits do you see about organ bioprinting and transplantation?		
Session Five - Attitudes and feelings about the bioprinting of organs and their transplantation			
15	Why would you choose to undergo the transplantation of bioprinted organs?		
16	To whom and why would you recommend the transplantation of bioprinted organs?		
Session Six - Expectations and hopes about bioprinting of organs and their transplantation			
17	How whoud you expect the organ bioprinting will change the medical practices (e.g., use for transplantation or other medical goals, keeping young, for living more)?		
18	How do the organ bioprinting and transplantation impact on your hopes about health and life?		

Table 1: Questionnaire Form.

Participant selection and recruitment

A purposive sample including potential donors and recipients (namely, patients) of regenerative implants was selected to conduct this study. This sample was chosen by supposing familiarity of these stakeholders with organ bioprinting and transplantation. Participants were recruited at the unit of Hematology of the Hospital Cà Foncello of Treviso that provides comprehensive services including tissue regeneration and transplantation.

Eligible candidates were approached by the volunteers of Adoces in December 2025 and the questionnaires were distributed from the 9 to the 31 December. Interested patients and donors were given concise information about the survey, according to the sheet included, and individual informed consent was collected.

The questionnaire distribution and the related study were approved from the Ethics Committee of the hospital Cà Foncello of Treviso that determined this research was in line with the national laws governing the medical practice [16,17].

Data collection

Nineteen questionnaires were collected from the volunteers of Adoces and then sent via e-mail to the researcher. This number was consistent with the piloting and qualitative nature of this study focused on the content of collected information rather than on the amount of responses.

Data were analyzed thematically and were reviewed to identify codes of text segments, categories and themes relevant the the research questions. Thematic analysis was chosen because it seemed to elicit the understanding of reasoning, decision making process and feeling [18].

After reviewing codes, categories and themes, representative quotes were chosen to illustrate the knowledge, opinions and feeling of patients and donors.

Results

The analysis of collected data showed the following themes (Table 2): 1) poor knowledge of bioprinting and regenerative transplants and the need for specific information, 2) the trust in bioprinting and regenerative implants, 3) enthusiasm for the potential benefits of bioprinting and regenerative surgery and 4) the perception of bioprinting and transplantation of artificial organs as a save-life technology or a measure to improve the qulaity of life of patients.

Resulting Themes	Quotations of patients (P) and donors (D)
Knowledge of bioprinting and regenerative transplants and need for specific information	"I do not know anything". (P) "I do not know a lot. I heard about it through media". (P) "I need explanations". (P) "I need more technical data". (P) "We need clear information". (P) "I need more information". (P) "It is something like cell culture". (D) "It is a technique reproducing tissues or organs". (D) "It regenerates tissues". (D) "We need consent". (P), (D)
Trust in bioprinting and regenerative medicine	"They are the future of medicine". (P) "It is something fabulous to give a chance to heal". (P) "New horizons for the research advances". (P) "I feel myself positive by thinking that this technology exists". (P) "Giving hope is not a bad thing". (P) "It is fabulous". (P) "Another step forward for science". (P) "A step forward for patient healing". (P) "Apparently it seems positive, I think it is something fabulous and innovative" (D) "It is the future of medicine that will allow to save more people" (D). "I trust in these technologies, they are innovative medicine" (D).

<p>Enthusiasm for potential benefits of bioprinting and regenerative surgery</p>	<p style="text-align: center;">Benefits</p> <p style="text-align: center;">“It is an healing therapy”. (P)</p> <p style="text-align: center;">“They improve the quality of life of patients”. (P)</p> <p style="text-align: center;">“It regenerates tissues and contributes to longevity”. (P)</p> <p style="text-align: center;">“Solution to the scarcity of available organs”. (P), (D)</p> <p style="text-align: center;">“A way to delete organ rejection”. (P), (D)</p> <p style="text-align: center;">“It improves the compatibility with organs thanks to the research”. (P)</p> <p style="text-align: center;">“A process to multiply the chances of transplantation without a donor”. (P), (D)</p> <p style="text-align: center;">“It allows to live better”.(P), (D)</p> <p style="text-align: center;">“They make the waiting lists shorter and they avoid the need for a compatible donor”. (P)</p> <p style="text-align: center;">“They solve the problems of organ failure”. (P)</p> <p style="text-align: center;">“It is a step forward for patient cure”, (P)</p> <p style="text-align: center;">“I do not think they can offer eternal life but improving they can improve it”. (P)</p> <p style="text-align: center;">Risks</p> <p style="text-align: center;">“Programming mistakes”. (P)</p> <p style="text-align: center;">“rsk of rejection”. (P)</p> <p style="text-align: center;">“Risks of abuse or fraudulent usage for whom an ethical code should be developed”. (P), (D)</p> <p style="text-align: center;">“If it works, I do not see any risk”. (D)</p> <p style="text-align: center;">“I do not see many risks because it is too far from the reality”. (P)</p>
<p>Perception of bioprinting and transplantation as a saving-life technology or a measure to improve the quality of life of patients</p>	<p style="text-align: center;">“Bioprinting is an added possibility to save my life and so it makes me feel calmer”. (P)</p> <p style="text-align: center;">“Bioprinting is an hope of life without a donor”. (P)</p> <p style="text-align: center;">“Save life treatment”. (P)</p> <p style="text-align: center;">“A saving life”. (P)</p> <p style="text-align: center;">“A treatment in particular cases or for particular diseases”. (P)</p> <p style="text-align: center;">“Prolonging life measures”. (P)</p> <p style="text-align: center;">“A way to live to the fullest”. (P)</p> <p style="text-align: center;">“They will give a cure and better quality of life”. (P)</p> <p style="text-align: center;">“They will have a good impact on the quality of life”. (P)</p> <p style="text-align: center;">“They will improve the life expectations in critical conditions”. (P)</p> <p style="text-align: center;">“They are an hope of life when there are no donors”. (P)</p> <p style="text-align: center;">“My hope is they will save lifes”. (P)</p> <p style="text-align: center;">“They will give options of curing when there is no any other chance”.(P), (D)</p> <p style="text-align: center;">“I hope they will permit new applications in medicine”. (D)</p> <p style="text-align: center;">“They will allow to treat diseases in particular conditions”. (D)</p> <p style="text-align: center;">“They are saving life and better life”. (D)</p> <p style="text-align: center;">“They are alternative to normal protocols”. (D)</p>

Table 2: Themes and quotations of patients and donors.

The knowledge of bioprinting and the need for specific information

The poor knowledge of bioprinting and transplantation of artificial organs was largely recognised by the participants to this study (Table 2). Patients said: “I do not not anything”, or “I know poor, it is the first time I hear about that” or “I know poor,

I heard of bioprinting through the media”. Among donors the prevalent response was the association of bioprinting to “tissue development” or “cellular culture” or “tissue regeneration” (Table 2). All the participants recognized the need for more information: “I need explanations”, or “We need clear information”. Some of them specifically required “more technical information” and “consent”.

The recognition of a poor knowledge of bioprinting and of artificial transplantation is not surprising because they are still at their infancy in the medical practice worldwide. To date the performed clinical trials are not numerous, though successful [19,20]. The media talked about them [21] but bioprinting and especially transplantation of artificial organs are not yet a common topic outside of the scientific community.

The trust in bioprinting and regenerative implants

The trust in science and innovative medicine was the main reason underlying the favor of patients and donors for bioprinting and bio-artificial organ transplantation.

Regenerative implants were seen as “the future of medicine”, or “something fabulous to give a chance to heal”, or “new horizons for the research advances” (Table 2).

A patient replied: “I feel myself positive by thinking that this technology exists”. Another said: “Giving hope is not a bad thing”.

The prevailing feeling among the study participants was the trust in bioprinting and artificial organ transplantation. This trust relied on the unconditional trust in science and its advances. Stakeholders did not mention worries about these technologies.

The optimism for advantages of bioprinting and artificial surgery

The trust in science and its related applications flowed out in the participant perception of benefits related to bioprinting and regenerative implants. In contrast, the risks of these technologies remained on the ground of the scene.

Patients and donors largely saw the bioprinting and transplantation of bio-artificial organs as a “healing therapy” or a technology that “improves the quality of life of patients”, or “regenerates tissues and contributes to longevity” (Table 2).

Moreover, many respondents considered the bioprinting and the regenerative surgery as a “solution to the scarcity of available organs” or “a way to delete organ rejection. Several participants considered the fabrication of bioartificial organs as the solution to the critical problem to find compatible donors by defining the bioprinting as “a process to multiply the chances of transplantation without a donor” (Table 2).

Despite the recognition of potential benefits, the perception of the risks associated with bioprinting and regenerative implants was low. Some participants mentioned the eventuality of: “programming mistakes”, or “risk of rejection” or “risks of abuse or fraudulent usage for whom an ethical code should be developed”. Others said: “if it works, I do not see any risk” or “I do not see many risks because it is too far from the reality”.

Bioprinting and regenerative implants as save-life or quality improvement techniques

The hope that bioprinting and regenerative implants save lives and/or improve the quality of life of sick people were the common reasons underlying the choice of participants to undergo a transplant of bio-artificial organs as patients or donors.

In particular these technologies were mostly considered as save-life treatments to be used in critical cases or when there was not any other option, including the lack of available donors. One participant said: “bioprinting is an added possibility to save my life and so it makes me feel calmer”. Other replied: “bioprinting is an hope of life without a donor” or a “save life treatment” or simpler “a saving life”. Others also said that it is “a treatment in particular cases or for particular diseases”. Moreover, some respondents (namely donors) considered the bioprinting and the regenerative implants as “prolonging life measures” or “a way to live to the fullest” (Table 2).

Hopes and attitudes of participants seemed to be consistent with their positive perception of bioprinting and regenerative transplantation as previously described.

Discussion

This pilot study contributes to the emerging literature about the knowledge, perceptions and attitudes of patients and donors towards the bioprinting and the transplant of bio-artificial organs by highlighting several themes that deserve deeper consideration in further research.

As previously seen, the knowledge of patients and donors about the bioprinting and the related applications is currently poor and more information (especially technical) are required. These data highlighted an issue that is largely debated in the ethical literature and concerns the kind of information that should be given to the patients and broadly the lay public about these technologies.

The prevailing position in the literature encourages a responsible approach to innovation that builds and maintains long-term trust in research and the development of regenerative medicine applications. Several studies recommend that scientists are especially careful when communicating with patients, physicians or other stakeholders in order to avoid or limit misperceptions and overly optimistic expectations [1]. In particular, they invite researchers to refrain from early or inaccurate representation of research and avoid to share findings with the press before deep investigation are performed by peer experts.

With regard to the consent, specific information on the bioprinting and the regenerative surgery applications should be given to patients and/or donors by clarifying foreseeable risks, benefits, safety measures and impact on their quality of life. Giving clear and thoughtful information to the patients and/or donors could mitigate the overly optimistic perception of benefits of bioprinting and regenerative transplant and the correlated unbalanced evaluation of their risks.

Meanwhile, the ethical principle of a reasonable evaluation of risks and benefits could change the perception of participants about the effects of the emerging technologies. This principle states that risks of participations in research should be outweighed by expected scientific and/or social value and potential advantages [22] of bio-artificial organs, the direct benefits to participants are currently limited and uncertain. At the same time, the expected benefits for the science and the society are supported by evidence only in few clinical trials [19,20] that, though successful, do not solve the uncertainty of these promising practices.

At the moment, however, stakeholders expectations about the bioprinting and regenerative implants are fed from great hopes. Study participants considered these technologies as strategies to heal sick people or improve their quality of life. In particular participants hoped that regenerative implants offered an efficacious treatment to patients at the ending stage of their life.

The participants association of the bioprinting and regenerative implants to “ending life” treatments is in line with the current literature about the selection of eligible candidates to early-phase clinical trials. Several studies consider people with limited life expectancies eligible to the transplant of bio-artificial organs because of the associated greater medical benefits.

Finally, the hopes of patients and donors offered a new element of discussion to the current literature by interpreting the bioprinting as a technique to fabricate organs viable for transplantation without the longer need of compatible donors. This perception is limited to some participants and it is potentially biased from the poor knowledge of stakeholders about the bioprinting and transplantation as well as from their underestimated perception of risks associated to these technologies. However it underlines the favor of patients and donors for the use of bio-artificial structures in place of biological organs. This feeling offers an interesting point of view for interpreting the ethical issue of the fabrication of body parts by highlighting the favor, rather than the concerns, of participants. The intersection of regenerative medicine and 3D bioprinting offers a future where organ shortages are perceived by the stakeholders as a thing of the past. The richness of the ethical implications of this perception deserves to be considered deeply in further research.

Limitations

This study has several limitations. First, it uses a purposive sample that represents a small portion of candidates eligible to receive a regenerative implant. Though this selection is consistent with the piloting nature of this study, further research should be performed with a larger sample engaging patients and donors that are candidates to several types of organs transplantation like, for example, bladder or kidney or lung transplantation. Expanding and differentiating the sample composition could give a more comprehensive representation of the viewpoints, perceptions and attitudes of the stakeholders about the bio-printing and the transplantation of bio-artificial organs. Second, qualitative questionnaires have numerous advantages (namely, thoughtful responses, reduced bias, ease logistic and more comfort for respondents). However, they do not allow the researchers and/or interviewers to see the interaction between the study participants, as in the case of oral interview. Moreover, they do not permit a direct interaction between the investigators and the people interviewed. Further studies should be conducted to explore the same themes by doing oral and in presence interviews in order to enrich the analysis through the participants and/or participants-interviewers interplay. Third, this study engaged only participants living in Italy. Further research could be performed exploring the same topics with patients and/or donors living in other countries. An international qualitative study on the knowledge, perceptions,

attitudes and hopes of the stakeholders about the bioprinting and the related applications could highlight eventual differences based on the language, culture, scientific evolution of the concerned country.

Despite these limitations, this study offers a contribution to the poor literature on the qualitative analysis of the patients and/or donors knowledge, understanding, expectations and hopes of the bioprinting and the transplantation of bio-artificial organs. Furthermore, it addresses themes that hold relevance for the field of bioprinting and regenerative surgery, offering critical elements to revise the current literature as well as to improve the existing practices of the transplantation of bio-artificial organs.

Conclusion

Bioprinting and regenerative surgery are opening new frontiers in the field of transplantation. Recently, early-phase clinical trials showed the potential of these technologies to make available life-saving therapeutic products to patients suffering from end-stage organ failure and to remove the need of life-long immunosuppressive therapy. However, these scientific advances raise critical ethical issues that deserve to be considered carefully.

This study explored the knowledge, perceptions, attitudes, expectations and hopes of patients and donors about the bioprinting and regenerative transplants by eliciting their ethical feeling about these techniques.

Research findings showed that interviewed stakeholders trust in the bioprinting and transplantation of bio-artificial organs and hope they could be a cure for ending-life patients as well as a definitive solution for organ failure.

Obtained results provide a valuable step to emphasize the need of further qualitative research exploring the patients and donors feelings and attitudes towards these emerging technologies. Further evaluation of these insights and other relevant ethical aspects of personalized bio-artificial organ transplantation should take place with a broader pool of stakeholders in parallel to the advances of regenerative surgery. In this way, a patient centered approach could inform the development of the bioprinting and regenerative surgery and provide guidance for their ethical and responsible development.

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Conflict of Interest

Nothing to declare.

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