



Current Research Progress in Stem Cell Therapy and Tissue Engineering Using Decellularized Materials

Anjali Oak ^{a*#}, Swati Singh ^{b†}, Asim Mustafa Khan ^c
and Prateek J. Pachore ^{d†}

^a Faculty of Dentistry, Sankalchand Patel University, Visnagar, Gujarat- 384315, India.

^b Department of Pediatric and Preventive Dentistry, Hazaribag College of Dental Sciences and Hospital, Jharkhand, India.

^c Department of Biomedical Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, India.

^d Narsinhbhai Patel Dental College & Hospital - Visnagar, Sankalchand Patel University, Gujarat -384315, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study clearly aims to describe the advancements of the researches that are made of stem cell and tissue engineering. It also aims to provide the objectives of using decellularization.

Study Design: The study is based on the secondary qualitative analysis of primary resources collected from previous researches. The systematic review that deals with the solutions of the raised challenges in the PICO model has been performed in this research.

Methodology: Methodology of the study deals with the testing of the uses of stem cells and tissue engineering so that new and innovative methods can be made in the field of tissue and organ

[#]PhD Scholar,

[†]Senior Lecturer,

*Corresponding author: E-mail: oakanjalia@gmail.com;

transplantation. The methodology also describes the way of the collection of data from several databases. The data has been collected on the basis of the answer of drawn research question in the research.

Results: The result deals with the meta-analysis of the secondary sources chosen for this research. Characterized features of the stem cells and tissue engineering in different field of the diseases. The result also discusses the factor that there must be the implementation of scaffolds from different organisms. It is thus analysed to be the part of tissue engineering and tissue engineering there must have some developmental stages of the ECM matrix. The implementation of plant tissues has been observed to a promising result. The sections from different field of stem cell therapy has been collected together to bring out advancements in the stem cell therapy. The findings suggests that to increase the efficacy of the stem cell therapy and tissue engineering cross kingdom connections such as taking decellularized tissues from plants must be implemented.

Conclusion: The study concludes that the uses of stem cells and use of plant scaffold can be determined. It is also concluded in the study that there is not highlighting gaps that have been analysed in the advanced field of decellularized implementation for stem cell therapy. This means the use of decellularized components, be it for plants or even from animals can bring up better results for the redevelopment of tissue engineering.

Keywords: Stem cell; tissue engineering; decellularization; transplantation; scaffolds; ECM.

1. INTRODUCTION

Stem cells preservation has become an exquisite process of development in the medical field. It has been justified that the preservation process is relatively longer than any other developmental process of the organs in humans [1]. Stem cell therapy is a regenerative medicine that promotes repair responses of any deadly diseases. The stem cells are being preserved during the birth of the child and it is recognized to be contributing for the curing process of any diseases. It has been man infested that the stem cell therapy is an attractive and strong approach of genetically engineered step that has shed the light in the path of diseases curing mechanism [2]. The time span takes from being an embryo to an adult stage in mammals. Additionally spermatogenesis can take place with the help of stem cells. It shows the progress of the research dealing with stem cells. Despite being a monolayer culture, it shows three dimensional structures in the agarose gel electrophoresis [1]. That, in turn, helps to determine the chromosomal structure that is being visited by the stem cell. Surprisingly, even after being preserved for a long period of time the stem cell never shows any ineffectiveness in its culture for any research field. On the other hand, cardiovascular diseases have become a matter of concern nowadays. As an example ischemic heart can be typically manifested as a disease that obstructs the blood flow to the heart [3]. This in turn might cause myocardial dysfunction and the ultimate death. Stem cell therapy offers an excellent solution for regenerating the

myocardium. On the contrary, tissue engineering opens up a pathway for regeneration of tissues. Tissue engineering is a better process that deals with the development practices that combined with scaffolds and other related biologically active molecules. Tissue engineering helps to rebuild the damaged tissues [4]. The differences can thus be highlighted between their stem cell therapy and tissue engineering as the stem cell therapy helps in healing the diseases however, tissue engineering helps in recovering the damaged tissues. In this case it can be stated that the both of them can be put together to build a better and innovative treatment method.

Progressive researchers have justified that it mainly relies on the tissue culturing and engineering mechanisms [5]. In addition to these words, it can be stated that both stem cell preservation and tissue engineering gives an innovative solution for the arising diseases related to the organs of the body. Additionally, decellularized materials are considered to be the low immunologically arisen materials that are needed to be removed [6]. It can thus be stated that stem cell and tissue engineering has become an enlightened source to get rid of tissue-related diseases. This study aims to provide a brief description of the research dealing with the progression of stem cell therapy and tissue engineering in the decellularized materials. The main objective of this study is to deal with the features of stem cell and tissue engineering in decellularized material. The objective also deals with the recent resources made on stem cell therapy and tissue

engineering. The accuracy of the treatment that deals with stem cell therapy has become a question. It is thus necessary to identify the key features required for the analysis of the stem cell therapy with decellularized material. Thus the research question defines the criteria that are required to be used in the analysis of the medical field with the help of stem cell approaches.

2. BACKGROUND

Stem cells and tissue engineering have done wonders in the field of research. It has been noted that in every field, advancements are required to build a strong base of the study. Decellularized materials consist of low immunity alongside sterilization procedure is required by them every time [6]. It is thus necessary to analyze the necessity of decellularized material as it is the removed cell from the tissue and it retains many inherent components. The evidence of graft survival has been taken into account as there is no other option to treat the cardiovascular diseases with essence. Apart from this, it is also required to be analyzed that there must be a therapeutic treatment for every deadlier disease that can be less painful to the patients [2]. A disorder that arises in the central and peripheral nervous system is vast and indeed a heterogeneous disease [7]. It has been noticed that hundreds and thousands of people get affected with neurological disorders and die mostly because of failing to respond to effective treatments. Stem cells have many aspects of revolutionizing the way of creating different treatments methods for cell or tissue-related diseases. An adult heart, even being a complex structure, has a very low regenerative capacity. On the other hand, heart failure has many reasons to occur and disrupt the body's functioning [3]. Additionally, by retaining inherited materials and components as a scaffold material or proteins it gives a positive solution for stem cell therapy. However, there have arisen many cases that do not deal with any medical treatment or even when the treatment is present it might be painful. Despite having a plethora of surgical activities in terms of therapies, the body is unable to regenerate the myocardium. To all these issues stem cell therapy has been proven to be a promising and excellent measure to regenerate myocardium. On the other hand, acute respiratory distress syndrome raises pulmonary fibrosis [8]. It can thus be stated that the progression of pulmonary fibrosis has

occurred mostly due to the outbreak of Covid-19. As stem cells have the potential of self-renewal along with a multilineage differentiation. This, in turn, makes an attractive modality for cell therapy. On the contrary, it has been noted that inflammatory bowel disease has also raised a concern for growing ulcers in the digestive systems. In order to reduce these mesenchymal stem cells therapy has been applied in this aspect [9]. Stem cells have been migrated towards the injured areas and help to regenerate. Additionally, tissue engineering is required for the treatment of liver diseases. Additionally, tissue engineering is required for the treatment of liver diseases. It has been manifested that the diseases related to tissues such as liver diseases, lungs diseases can be somewhat managed with the help of tissue engineering. However, tissue engineering is only capable of healing the damaged tissues and not curing the entire disease. In order to achieve that progress it is necessary to put forward the stem cell therapy [4]. Chronic liver disease that arises from viral infection might create a misbalance in the liver functioning and ultimately causes liver failure [10]. Although there are several advances that show a variation of the treatment approaches in the medical field related to stem cell therapy and tissue engineering. However, not much advancement has been seen in porter treatment and diagnosis methods of different issues and diseases. Tissue engineering embraces the potential recreation of defective parts of the body [11]. It helps to replace the affected area with the new histological structure. Hence, it can be stated that tissue engineering shows optimal performances for clinical applications [12]. Various advancements have been achieved at this position of tissue engineering that deals with signaling of growth factors. Cardiovascular diseases have also shown some success in the treatment when it has been done with stem cell therapy [13]. On the other hand, it has also been noticed that there are several other approaches that can be applied in the treatment methods. However, stem cells and tissue engineering deals with natural as well as artificial methods of regeneration of the organs. Hence, are very innovative and applied as an advanced structure in the field of medicine. The rising concerns of different issues related to the tissue disease can be mitigated through the implementation of stem cell and tissue engineering [6]. Describing decellularized material it can be illustrated that these materials are required for the stem cell culture as these

Table 1. PICO analysis

Patient	Intervention	Comparison	Outcomes
Disease category	Diagnostic tests Proper medication Experiments	Stem cell therapy	Symptoms maintenance Healthy living

(Source: Leonardo, 2018) [30]

materials are firstly sterilized and bacterial free. The issues and challenges in terms of analysis of the medical issues can be analysed with the help of PICO model.

3. MATERIALS AND METHODS

3.1 Database

The data bases are always being used to collect the data and the related sources required for the study. The data collected from Pub Med in terms of primary quantitative and secondary qualitative data respectively. The data has been collected on the basis of diseases category of the patient's based on e PICO model. This database gives a proper justification of the needs of resources. The collected data is thus then analyzed in the study, and a systematic review has been constructed. The data that are collected from the secondary sources are also primary quantitative data. In order to conduct the research with proper formats, the databases are required to extract the sources as those are important to conduct analyses for getting the outcomes of the study [Refer to Appendix 1].

3.2 Inclusion and Exclusion Criteria

Common inclusion and exclusion criteria serve with variables that are necessary for the study [14]. In this study, the variables have been extracted in the same way. The articles that are not much older than 7 years are included. On the other hand, articles that are older than 7 years are excluded that range from 2015-2021. The language of the resources other than English is excluded on the other hand the articles comprising the English language are included. Additionally, to conduct a thematic analysis 5 primary quantitative articles are being included. The keywords have been extracted from the sources that are being chosen in this research and are then described

accordingly. The features of stem cells and tissue engineering in decellularized cells are included.

3.3 Data Collection

Data collection is the technique of gathering the data required to conduct a study. In order to conduct an organized study, it is necessary to collect the data with proper solutions and materials. Each secondary source of this study consists of primary quantitative data that have been used to generate thematic analysis for the study. The articles are selected based on Prisma model as depicted in Fig. 1. Data collection deals with the internet of things are it primary or secondary [16]. In contrast to this statement, it can be stated that collection of data requires the internet and its sources to conduct a study. The variables and factors that are being used in this study show the collection of data from primary quantitative articles. The data that has been collected in the form of secondary sources have been appraised to check the quality. Secondary sources have been collected that are based on the challenges and solutions rising in the given topic. The systematic review that deals with the advancements of the treatment process or even the research process with stem cells and tissue engineering require more advancements and knowledge. The implementation of such a technique is required so that improvement in the medical field can be achieved. The data has been collected from the databases that would provide better ideas about the issue of tissue regeneration and implementation of stem cell therapy techniques.

4. RESULTS

The result section determines the analyzed themes and the need of the reviews of the article that are collected for the study. A Boolean table has been prepared that shows the keywords that are being achieved from the study [Refer to Appendix 2].

4.1 Prisma for the Selected Articles

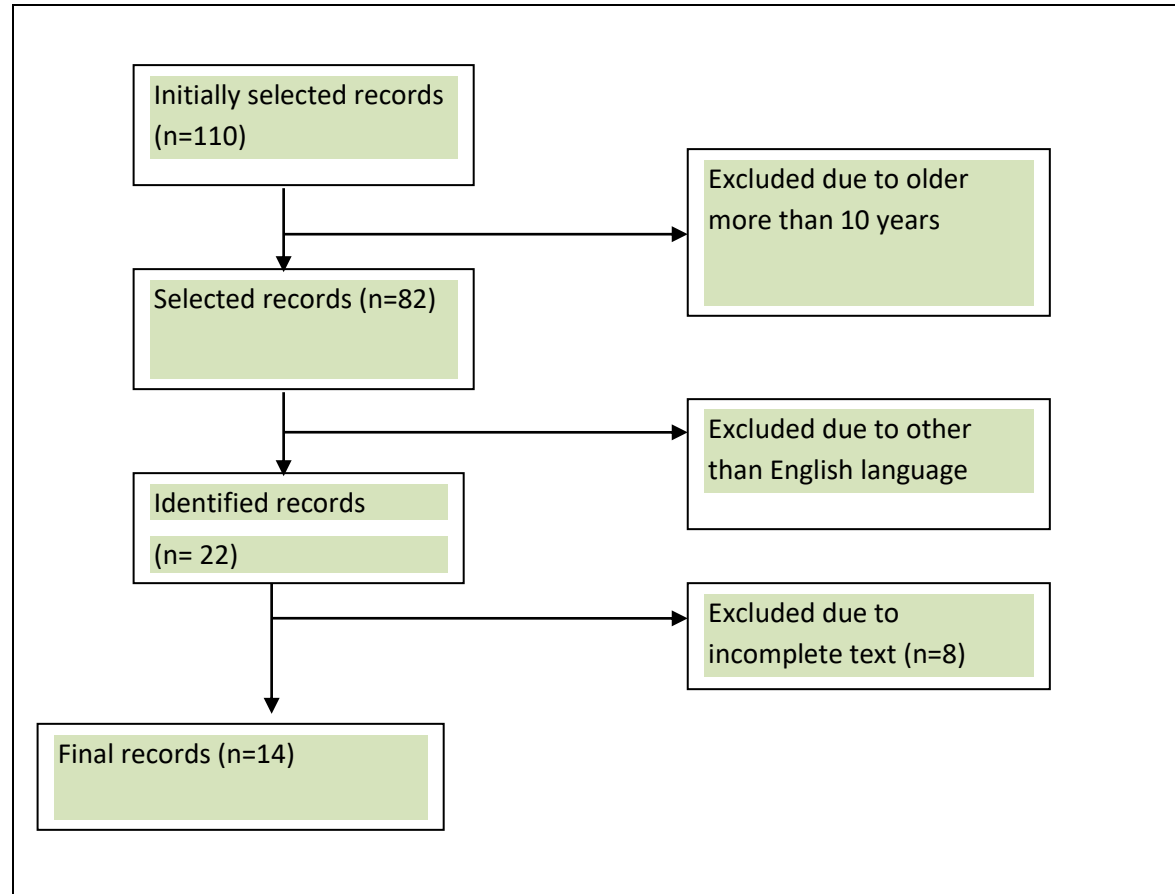


Fig. 1. Prisma diagram

4.2 Quality Review

Table 2. Quality review table

Authors	Study design	Accuracy in addressing the issue	Accuracy of outcomes	Proper identification of factors	Sufficiency of subjects to meet the objectives	Confounding of the factors have been done
Aamodt et al. (2021)	Primary quantitative	High	High	Yes	Yes	Yes
Cheng and Ya-Wen (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Gao et al. (2021)	Primary quantitative	Medium	High	Yes	Yes	Yes
Gershlak et al. (2017)	Primary quantitative	High	High	Yes	Yes	Yes
Grebenik and Ekaterina (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Jang and Jinah (2017)	Primary quantitative	Medium	Medium	Yes	Yes	Yes
Jeong and Gun-Jae (2018)	Primary quantitative	Medium	High	Yes	Yes	Yes
Kakabadze and Zurab (2019)	Primary quantitative	High	High	Yes	Yes	Yes
Liao and Jie (2020)	Primary quantitative	High	Medium	Yes	Yes	Yes
Rana et al. (2017)	Primary quantitative	High	High	Yes	Yes	Yes
Reginsiet et al. (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Sartet et al. (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Xing et al. (2020)	Primary quantitative	High	High	Yes	Yes	Yes
Zhou et al. (2015)	Primary quantitative	High	High	Yes	Yes	Yes

4.3 Axial Coding

Table 3. Axial coding table

Authors	Codes	Theme
Aamodt et al. (2021) Sartet et al. (2020)	Organ, decellularization, extracellular matrix	Understanding of the stem cell and tissue engineering in the characterization of the biological treatments by using scaffolds of ECM as a biomaterial
Cheng and Ya-Wen (2020) Xing et al. (2020)	Engineered tissues, decellularization, human skeletal muscles	Analysis of the engineering of aligned skeletal muscles tissues with the help of tissue engineering by using plant-derived scaffolds and also its uses in cell functioning
Zhou et al. (2015) Gao et al. (2021)	Cell orientation, proliferation, migration, tissue engineering	Determination of the stem cells with decellularized scaffold in regenerating liver and its application
Gershlak et al. (2017)	Regenerative medicine, decellularization,	Analyzing the regulation of myogenic differentiation by tissue engineering Evaluation of the tissue engineering techniques by implementing plant that are

Authors	Codes	Theme
Rana et al. (2017)	perfusable scaffolds	decellularized as perfusable tissue scaffold Developing the needs of the decellularized scaffold in generating stem cell-driven tissue engineering process
Grebenik and Ekaterina (2020) Liao and Jie (2020)	Xenotransplantation, tissue engineering	Implementation of the advanced techniques in Xenotransplantation and tissue engineering Identification of the applications of the decellularized materials in tissue engineering
Jang and Jinah (2017) Reginensiet al. (2020)	3D printing, hydro gel, stem cells, tissue engineering	Constructing of the 3D printed tissue using stem cell therapy and implementing the bioinks for cardiac repair Determination of the role of extracellular matrix in neural maturation
Kakabadze and Zurab (2019) Jeong and Gun-Jae (2018)	Animal model, bioactive factors, bone marrow stem cell	Treatment of the non-healing wound using stem cell and bone marrow therapy after radiation therapy Improvement of mesenchymal stem cell engraftment for angiogenesis

4.3.1 Critical understanding of the need of stem cell therapy and tissue engineering in repairing the non-healing wound of the organs

Non-healing wounds remain active in the body and it contributes to the generation of new diseases that are hard to cure. It is necessary to analyse the use of stem cell therapy and tissues engineering as it can bring out changes in their form of therapeutic treatment. Tissue engineering has been found to be a strong approach for treating of the diseases. There are so many therapies that deal with stem cell and tissue engineering and one such therapy named radio therapy has been used in this research. A radio therapeutic treatment is very common among cancer patients [17]. It has been noted that there are several aspects of stem cell therapy and tissue engineering of the regeneration of new cells so that the wound can be cured. In contrast to this statement, it can be stated that cancerous patients after going through radiotherapy might get several injuries internally. Bone marrow stem cells increase the rate of wound healing much faster than any other method [17]. On the other hand, stem cell therapy is also well known for curing ischemic disease. However, in some cases the poor engrafting of the stem cells limits the efficacy [18].

Fig. 2 depicts cells are firstly cultured in the culture plates using several enzymes such as DNase [18]. Additionally, it can be justified that these therapies can work properly even in the chronic wounds. The recent advancements suggest that the development and curing of the wound can be analyzed by using scanning electron microscopy [17]. Various achievements have been achieved in this field as different bioactive materials such as declared scaffolds can now be produced from the plants too [17]. However, the viability of the wound healing process is being dependent of the human adipose tissue-derived stem cells [18]. It might be because the more fat layers might increase the time of healing due to excess secretion of fluids in the adiposities. It has been noted that in the cases of fat disposing tissues such as liver, the tissue engrafting becomes the only solution to treat wit with proper essences. The common aspect between the decellularized materials and stem cell therapy is in both the cases the cells are being grafted before putting it into the body of the patients. It is necessary to evaluate the decellularized cells with that of stem cells in order to get better and unique biological properties.

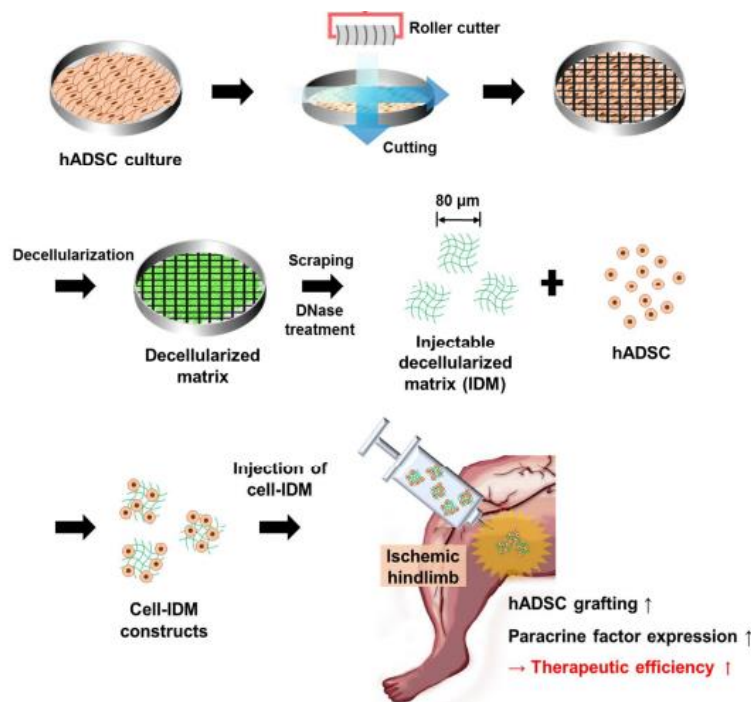


Fig. 2. Diagram showing decellularized injectable matrix *in vivo* experiment
(Source: Jeong and Gun-Jae, 2018)

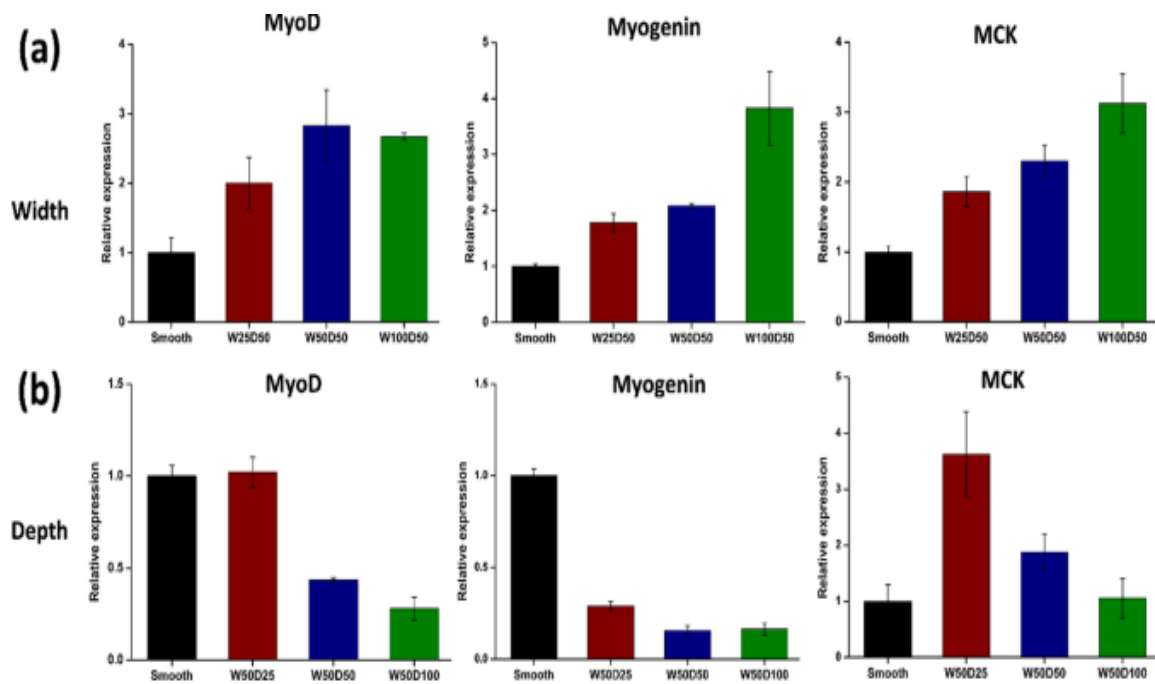


Fig. 3. Implementation of the stem cell to check the growth factors in stem cell therapy
(Source: Zhou et al. 2015)

4.3.2 Critical evaluation of the functions of stem cells with decellularized scaffold in regenerating the healthy hepatic cells

Stem cells are the key to achieve a healthy and better treatment, including life with its own tissues and cells. It has been noticed that the preservation of stem cells has become an important part in today's world as it would help to support the immune system to fight tissue-specific diseases. It has been observed that end-hepatic failure has become a potential life-threatening disease nowadays [19]. Organ failure in terms of treatments of their liver diseases is very common as it does not include any golden treatment method. The function of the decellularized material with respect to stem cell therapy has been individually identified in order to show the efficiency of each method.

It has also been noted that there is a shortage in the availability of the liver donor and that in turn causes death to the patients. On the other hand, primary transplantation of hepatocytes has also rarely produced the therapeutic effects as mature hepatocytes cannot be expanded properly [19]. Additionally, it has been observed that cell orientation might also affect the expansion of surface areas required for the formation of the new cells [20].

However, in this aspect, tissue engineering has given wonderful results as it has helped in the reconstruction of tissue functioning. It has been noted that decellularization technology can largely impact on the preservation of the composition of the liver and helps to ensure biocompatibility [19]. This shows the requirement of stem cell implementations in the transplantation mechanism. However, on many scales, the liver can show dysfunctioning, such as in the case of cirrhosis there is no treatment that can cure a damaged liver. On the other hand, liver injury and complexities due to ulcer can be treated by using stem cell therapy. **Fig. 3** justifies the presence of transcriptional regulatory proteins such as Myogenin, MyoD and MCK that reveal the morphogenetic evidence in the stem cell therapy. It can be observed that the depth and width are different in terms of expression of the regulatory proteins [19]. The expression of such regulatory cofactors can be proved to be better marker.

4.3.3 Critical evaluation of the Xenotransplantation and tissue engineering using mammalian pericardium based bioprosthetic material

Bioprosthetic material that is based on mammalian pericardium is a very essential

standard in reconstructive surgeries. It has been noted that this has gained an extensive usage in the field of reconstructive surgery [21]. On the other hand, it has been manifested that with an increasing technological environment, it is necessary to put forward the use of biomaterials in the medical fields so that the achievement of surgeries can be achieved [22]. Biomaterials are preferred because they possess a good compatibility and non-toxicity. Likewise the use of bioprosthetic material is being analyzed having similar features with biomaterials. However, there are efforts that are being given in the preparation of the prosthetic material [21].

It has been noted that nowadays stem cell therapy and tissue engineering is being performed using decellularized material. The above-mentioned figure thus shows the needs of biomaterials to perform any reconstructive surgery [22]. On the contrary, decellularized materials are removed from cells and tissues and thus contain antigenic components that can help in the formation of constructs in the surgical processes [21]. The mechanical properties of bioprosthetic materials are estimated and have also been observed to be having tensile strength and flexibility [22]. It is thus can be stated that there is a need for tensile collagen fiber that can create a proper reconstructive structure after a successful surgery. Although there are many other approaches such as artificial reconstruction of constructed tissue from bioprosthetic and biomaterials are essential and easier to be used. Fig. 4 signifies projected researches that are dealing with decellularized materials in terms of

stem cell therapy and tissue engineering. Their decellularized materials contain tissue specific environment that gives a positive result in the process of stem cell therapy. Hence, it is necessary to use decellularized tissues as it helps to grow much faster in terms of regeneration in the stem cell therapy.

4.3.4 Critical understanding of the need of development of decellularized scaffold from plants as perusable tissue for stem cell and tissue engineering

A large number of researches have been performed that is based on the scaffold of human beings for stem cell therapy or tissue engineering. However, it creates a significant challenge for the researchers as human tissue requires a longer time for regeneration and sometimes shows failure too [23]. Organ transplantation is a significant approach of replacing and removing the injured or unhealthy tissue and organs from the body [24]. On the other hand, it has also been observed that there are many issues in getting donors for the transplantation process. It is the reason for opting for the decellularized materials to perform the transplantation. Additionally, it has been observed that decellularized biomaterials from human organs such as intestine, kidney, liver and many more get evaluated on this priceless [24]. In this aspect, it can be stated that expanding the cross-kingdom that means expanding the decellularized materials of the plant has been proven to be a better approach [23].

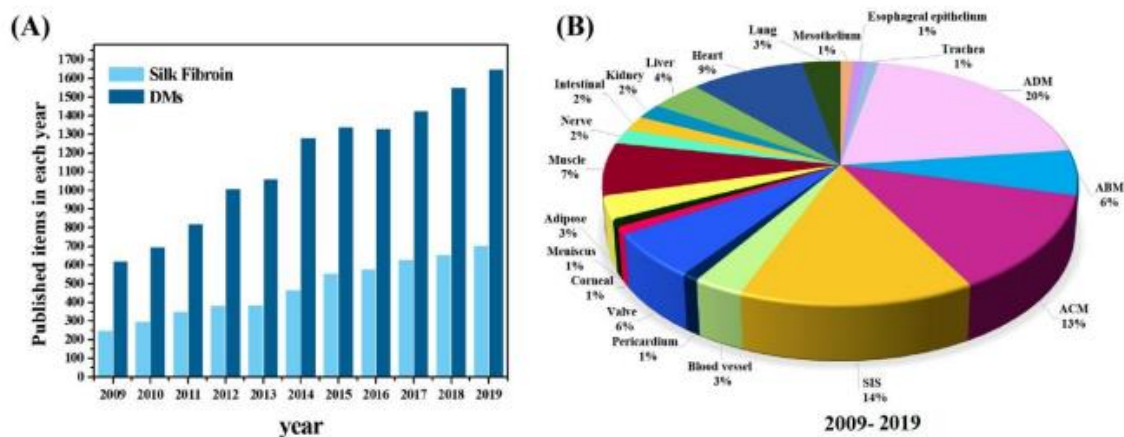


Fig. 4. The data shows current research conditions of decellularized materials (Source: Liao and Jie, 2020)

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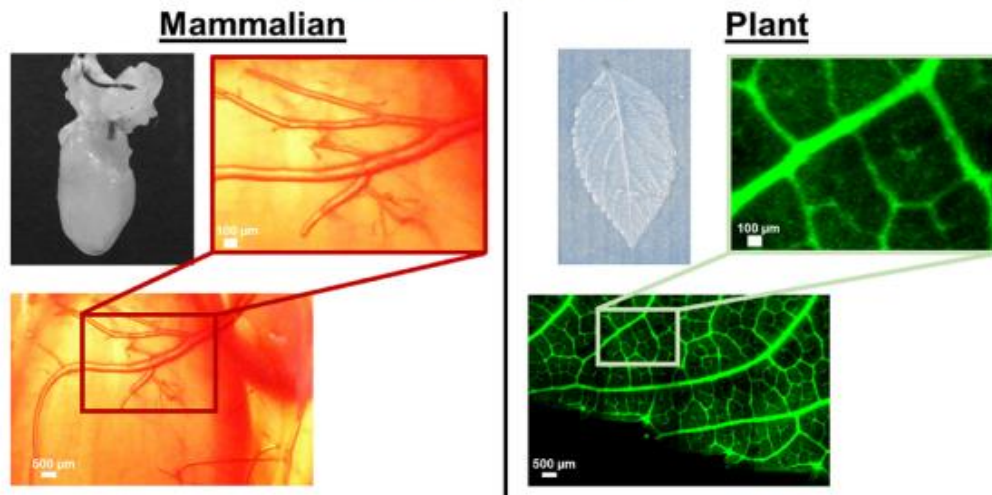


Fig. 5. A cross-sectional study of the decellularized materials from animal and plant
(Source: Gershlak et al. 2017)

Perfusion based on plant species is modified and it helps to generate tissue constructs [23]. It has been noted that human mesenchymal stem cells always tend to adhere to the outer surfaces of the plant scaffold. The advancement in the research has been taken into account because there are medicines that can be collected from the plants and can be used for the animals. Likewise the use of plant decellularized material is being taken into account in case of tissue grafting in mammals. It might be because of the fact that the successful rise grafting from the plants can be less painful and less expensive. In Fig. 5, both the cross section of the mammal as well as plant tissue has been given those shows similarities between the plant and animal tissues. It is easier to generate plant-based scaffolds because it helps the structure of the plant to be less complex than animal structure [24]. On the other hand, histological analysis also suggests that tissue engineering has made wonders in the present days. However, there is a need for stem cell and tissue engineering to provide a structural component of the regeneration of unhealthy tissues.

4.3.5 Comprehensive analysis of the advantages of stem cell therapy and tissue engineering in biological treatment using scaffold of ECM

Extracellular matrix components or proteins are the collective sources of the naturally occurring proteins that play vital roles in stem cell culture and tissue engineering [25]. The formation of

ECM has been ongoing since decades. It has helped to reach the advanced strategies of organ transplantation. However, in most of biological processes, there remain complexities that are hard to be dealt with. It is thus necessary to bring advancements in the medical fields so that fruitful results can be achieved. On the other hand, stem cells including potent cells have attracted attention towards the tissue engineering purposes [26]. However, regenerative medicines are hard to be established thus it is necessary to implement self renewal properties of the organs by performing tissue engineering. It has been analyzed that stem cells bear unique ability to deal with regenerative properties [26]. However, to conduct stem cell therapy, it is necessary to implement decellularized cells and matrices that are mentioned in the earlier section of the study. In contrast to this statement, it can be stated that ECM functional properties can provide a regular development of the scaffold by creating a microenvironment.

In the given figure, it can be analyzed that there is a composition of residual proteins that includes the DNA content and other non-native proteins that together make the ECM. Fig. 6 shows that not only the activators and the regulatory proteins and even the residual proteins are also contributing in the ECM formation of the liver. This fact has been analyzed in this section because residual proteins might hamper the grafting process that is being done on the basis of tissue engineering and stem cell therapy.

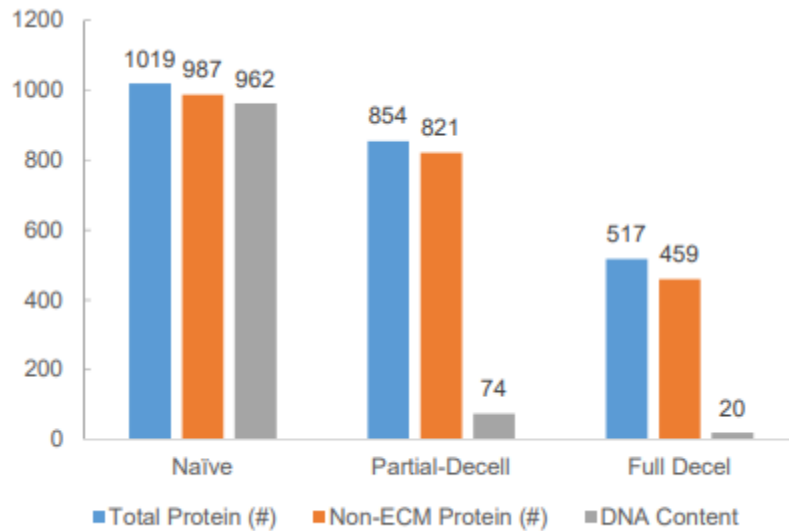


Fig. 6. Contribution of residual protein percent in the ECM of liver that contributes to the total amount of decellularized tissue
(Source: Aamodt et al. 2021)

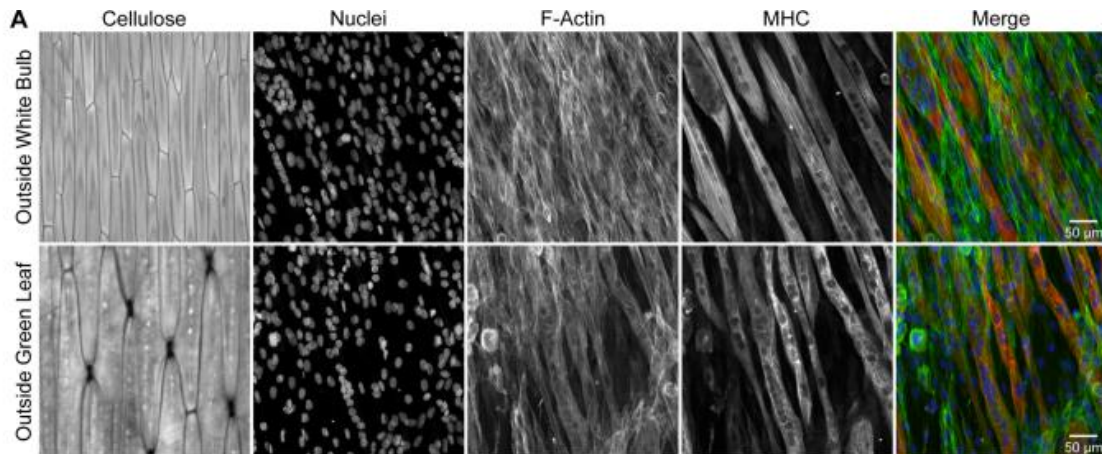


Fig. 7. Cell differentiation into aligned skeletal muscles that consists of plant scaffolds
(Source: Cheng and Ya-Wen, 2020)

It has been noted that removal of residual DNA and RNA or even protein from the ECM does not create much difference in the content on the ECM [25]. On the other hand, it has also been noticed that as the prevalence of RNase in the decellularization is relatively lower than DNase hence, there's not much difference being found. Additionally, tissue engineering has opened up the way of creating cell-engaging and mediating pathways. In contrast to this statement, it can be stated that stem cell therapy thus provides a better opportunity to lead a healthy life without implementing any artificial component in the body.

4.3.6 Critical understanding of the 3D printing construct of tissue using stem cell therapy along with determining the role of ECM in neural maturation

Stem cell therapy is a promising approach to treat ischemic disease of the heart, pulmonary fibrosis, hepatic disruptions and many more that are hard to count. It has been observed that 3D printed vascularized patches of stem cells can enhance the therapeutic efficacy in terms of cardiac repair [27]. However, it has also been analyzed that extracellular bioinks are being used to implement the 3D printing of the tissue construct. The bioinks are being extracted from

the decellularized ECM components. Additionally, it has been analyzed that recent advancements have suggested that the tissue engineering can serve a potentiate structure to the localization and efficacy of the stem cell therapy [28]. Surprisingly, it has been observed that the printed structure consists of the dual stem cell that improves the interaction between cells. On the other hand, 3D cell printing being a promising technology has precisely controlled organs by mimicking the shape of the inner and outer architecture of the tissues [27]. However, there is a need for 3D printing of the tissue constructs as the immunological test always deals with the inner complexities of the tissues. In order to analyses the raise challenges in that includes the dysfunctioning of the tissue required for emphasizing on the constructs printings. It has been noticed that stem cell therapy becomes easier in this step because it includes the growth factors that can help in the maturation of the neuronal tissues [28]. In contrast to this statement, it can be stated that as neuronal regions bear a very complex structure, it is necessary to that theme with proper analysis of the networks. However, to achieve such a treatment approach, 3D printing is necessary. The terms of 3D porting have been evaluated in this result section because the 3D imaging of the tissues would help to analyse the appropriate markers and receptors that are required to be induced in the process.

4.3.7 Analytical analysis of the tissue engineering in aligning skeletal muscle tissue

In order to achieve an organized function of the tissue constructs a scaffold is required. In cases of skeletal muscle tissue engineering and decellularization has been an approach of giving fruitful results [29]. However, while decellularization take the steps are basically includes the animal tissues. On the other hand, new approaches have been designed that show the needs of a plant's scaffold as a decellularized material to deal with tissue engineering. Additionally damaged skeletal muscle along with subsequent loss of function of the muscle might occur due to trauma and ageing processes [29]. On the other hand, it has also been analyzed that ECM plays a crucial role in maintaining the structure of leg muscles. It might be because the structure of ECM is tensile and it helps to maintain the density of the collagen fibers. It has also been observed that ECM complaints have

become an emerging source of biomaterials in terms of tissue engineering [30].

In the above mentioned figure, it can be stated that the structure of cellulose is somewhat similar with the structure of F-actins. This means the ECM of plant scaffold can mimic the structure of the animal tissue providing a stable structure [29]. On the other hand, it has also been analyzed that plant tissue deriving materials are ideal for the skin. In contrast to this statement, it can be stated that there will not be any adverse effects on the skin by implementation of the plant material. Tissue engineering being an advanced technological mechanism has become a part of further development of the medical fields. Additionally, it can also be stated that there are various aspects that have shown the need of plant tissue in building the developmental stages in organ transplantation. Fig. 7 shows the cell differentiation of the muscle cells of mammals that are being grafted with plant scaffolds. In this aspect it can be stated that the results related to the differential pathways of using tissue engineering can be proved to be an innovative process. In this case the plant cells could merge with the animal cell that shows there diversification of inductivity are similarities between the plant and animal cells.

5. DISCUSSION

All the authors agreed on the fact that tissue engineering has become inevitable and indispensable in case of repairing of wounds to internal organs. Furthermore the authors also agreed on the contribution of tissue engineering to irreparable liver damage. Further with the advent of science there is an increased usage of prosthetics for which tissue engineering is also significant. The improvement in the techniques has been shown with diversified examples in the result. It shows that there can be implementation of the stem cell approaches along with grafting procedures that can bring changes in the treatment field. The entire study thus concludes the needs of scaffold in maintaining the tissue engineering processes. In corresponds to the aim of the study it can be determined that stem cell therapy and tissue engineering have reached to large advanced sections. In the study the scaffold made from plant has been used as decellularized material for conducting the stem cell therapy. It has also been identified that the recent advancements of the stem cell therapy and tissue engineering using decellularized material. In the findings sections results suggests

that the advancements such as 3D printing, using plant scaffolds, using of ECM matrices as scaffolds and features of stem cell therapy can be implemented by applying different means of scaffold. However, it has been noticed that there is a complexity in using human tissues for the tissue engineering procedures, yet it is being performed to deal with damaged tissues. The need of decellularized materials has also been achieved in the tissue engineering and stem cell therapy. Findings suggests that the decellularized materials are the scaffold proteins from different sources. The advancements suggest that the scaffold can be extracted from the ECM Of animal as well as plants. It can also be suggested that as plant scaffolds can mimic the structure of animal tissues hence, it can be implemented. Recent researches have shown many pathways to use the plant scaffolds. However, native synthetic materials that are being used as artificial structure on the tissue engineering might trigger as fairing body responses [26]. Surprisingly no such disruption has been noticed in the case of the implementation of plant tissues as scaffolds in the body of the human. Additionally, it has been noticed that 3D prompting also opens up a channel for building RT-PCR or real-time polymerase chain reaction arrays [19]. The stem cell therapy thus have shown therapeutic efficacy in the medical field. It can also be stated that the study also relates the facts of the efficacy of the ECM components in conducting the stem cell therapy. The results also suggest that using of plant scaffold along with animal scaffold can also be taken place because both show more and less similar features. In cases of the skeletal muscles it has been noticed that the plant scaffold can mimic the structure of F-actins. This shows that instead of skeletal muscle scaffold, plant scaffold can also be used to achieved stem cell therapy and tissue engineering. The advancements also suggest that choosing of plant scaffold has been chosen because the availability of animal tissue is not adequately available. The main points of divergence includes the fact that few authors pointed out the challenges that are posed by application of tissue engineering but rest did not clearly mention the challenges owing to which the presented information on tissue engineering seems easier to implement but the real world scenario is different.

6. CONCLUSION

The study justifies the means of implementation of the stem cell and tissue engineering in the

medical field to get the advancements. However, recent advancements and research suggests that this e are allowed in progress, yet the needs of expansion of the kingdom and using decellularized plants for tissue engineering is also necessary. The study thus concludes that there is information of plant scaffolds from the ECM matrix so that advancement in the scaffold technology can be achieved. Result discusses the differential examples in terms of stem cell uses and application in different fields.

The result section concludes that using of decellularized material from different species can be achieved by implementing scaffold of living being from different kingdom. However, only the scaffold of plants has been tested to be mimicking the structure yet some advanced research can also be conducted that deals with scaffold of other species for stem cell therapy and tissue engineering. The adoption of ECM based matrices can thus be used as an efficient biomaterial for the tissue engineering process. In a nutshell it can be concluded that as ECM provides 3D structure if tissue scaffold therefore it can be implemented as a printing technique too.

CONSENT

It is not applicable.

ETHICAL CONSIDERATION

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.


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APPENDICES

Appendix 1: Database



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RESULTS BY YEAR




1 article found by citation matching

Applications of decellularized materials in tissue engineering: advantages, drawbacks and current improvements, and future perspectives.
Liao J, et al. J Mater Chem B. 2020. PMID: 33053004 Review.

Engineering Aligned Skeletal Muscle Tissue Using Decellularized Plant-Derived Scaffolds.

Cite Cheng YW, Shiwarski DJ, Ball RL, Whitehead KA, Feinberg AW.
ACS Biomater Sci Eng. 2020 May 11;6(5):3046-3054. doi: 10.1021/acsbomaterials.0c00058. Epub 2020



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RESULTS BY YEAR



Application of injectable hydrogels for cardiac **stem cell therapy** and **tissue engineering**.

Cite Alagarsamy KN, Yan W, Srivastava A, Desiderio V, Dhingra S.
Rev Cardiovasc Med. 2019 Dec 30;20(4):221-230. doi: 10.31083/j.rcm.2019.04.534.
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Stem cell sources such as adult **stem** cells, embryonic and induced pluripotent **stem** cells have been the focal point of research in cardiac **tissue engineering**. ...In this review, we discuss the various injectable hydrogels that have been tr ...



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RESULTS BY YEAR



Application of injectable hydrogels for cardiac **stem cell therapy** and tissue engineering.

Cite Alagarsamy KN, Yan W, Srivastava A, Desiderio V, Dhingra S.
Rev Cardiovasc Med. 2019 Dec 30;20(4):221-230. doi: 10.31083/j.rcm.2019.04.534.
Share PMID: 31912713 [Free article](#). [Review](#).

Conventional treatments lack the ability to treat the myocardium lost during an acute myocardial infarction. **Stem cell therapy** offers an excellent solution for myocardial regeneration. **Stem cell** sources such as adult **stem** cells, embryonic ...

Appendix 2: Boolean table

Keywords	And/or	Keywords
Stem cell therapy	And	Scaffolds
Tissue engineering	And	Plant tissue
Extra cellular matrix	And	Biomaterial
Skeleton muscle	And	3D printing
Decellularization	And	Xenotransplantation

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