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Exploring Stem Cell Therapy And Tissue Engineering Can Repair Or Regenerate Damaged Oral Tissues.

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Abstract

Background: Non-healing and contracting type of wounds caused by periodontitis and trauma of oral tissues are critical issues nowadays, as the conventional methodologies of treatment do not adequately reconstruct the tissue's functionality. Stem cell therapy and tissue engineering are being defined as two promising approaches that entrust the body's capacity for self-repair for the regeneration of damaged tissues to make new opportunities for dental treatment.

Objectives: To evaluate stem cell therapy and tissue engineering in regeneration of oral tissues in a cross-sectional study with 200 participants to be considered for clinical parameters, tissue healing, and restoration.

Study design: A Cross-Sectional Study.

Duration and place of study. Dental Hospital WATIM Medical and Dental College Rawalpindi from 05-jan 2022 to 05-july 2022

Methods: This was a cross-sectional descriptive study of 200 patients who were undergoing treatment for oral tissue damage with MSCs and biomaterials scaffages. Regarding tissue remodeling, function, and complication, the information was gathered and assessed. Descriptive measures for the findings were in form of means and standard deviations, while for the test of significance, t-tests or ANOVA were used apart from the p-value of less than 0. 05.

Results: This was a cross sectional, comparative, 'gold standard trial' conducted among 200 patients where MSCs derived from Periodontal ligament boosted the bone formation by 60%; (SD: ±12%, p<0. 01). Furthermore, the application of the dental pulp stem cells with the help of collagen scaffolds helped to regain 70 percent of a faulty periodontal tissue (SD = 15%, $p \leq 0.001$). In addition, demonstrably, stem cell-seeded scaffolds contributed a maturation of pulp tissue in 85% of the treated teeth (SD=10%, $p < 0.01$). These outcomes evidence the potential of stem cell treatment and tissue engineering in the improvement of oral tissue repair of a vast number of patients.

Conclusion: Stem cell therapy and tissue engineering provide evidence of fairly advanced outcomes in oral tissue reparative medicine, including enhanced tissue repair alongside improved tissue functionality. Based on these results, such innovative approaches may be poised to serve as components of future dental care oriented at the real repair of tissues damaged in various ways.

Keywords: Cell therapies, stem cells, tissue regeneration, dental therapy.

Introduction

Dental care is essential in one's health because the mouth is vital in eating, speaking and social aspects. There are various diseases for example periodontitis, caries and traumatic injuries that act as barriers to the maintenance of good oral hygiene. These conditions cause soft and hard tissue destruction in the oral cavity which may lead to tooth loss, bone resorption and dysfunction [1]. Current restorative dental procedures such as fillings, crowns and dentures mostly work on the restorative aspect of the damaged tissues without any thought of the lost bio function. Such a limitation points toward the future development of more complex treatment interventions that are attempting not only a structural repair of oral tissues but biological activity as well. The field of regenerative medicine offers stem cell therapy and tissue engineering as possible therapies in the regeneration of damaged oral tissues in the recent past. The cells with the property of differentiation and self-renewal are the stem cells that possess an unrivaled potential in replacing the damaged tissues. Among GSMCs, particular interest has been directed to MSCs which can be differentiated into odontogenic, osteogenic, and chondrogenic lineages, and, therefore, can be considered as promising for the dental and periodontal tissues regeneration [2]. Harvest sites MSCs include dental pulp, periodontal ligaments, and BMSCs each with its own pros and cons [2]. This is because tissue engineering takes the concept of stem cell therapy a notch higher by providing a scaffold that resembles the extracellular matrix which the stem cells need to organize and proliferate in a manner most optimum for the regeneration of the tissue [4]. Scaffold materials can be either naturally sourced or synthetically derived and consider cell adhesion, migration, and differentiation to happen while also being biocompatible and in some cases bioresorbable [5]. Integration of stem cells with biomaterial scaffolds has been proven worthwhile from experimental data which has thus pushed progress of regenerative dentistry. Among those diseases, periodontitis is the most severe chronic inflammatory disease resulting in the destruction of periodontal tissues, and it is one of the most important target diseases for those regenerative strategies. Currently available interventions serve to manage the infection and inflammation and arrest its progression but do not actively encourage growth of new tissues which are so vital as for instance alveolar bone and periodontal ligament [6]. Research work has demonstrated that it is possible to obtain regeneration of these tissues and their functions and appearance with the use of MSCs incorporated in tissue-engineered scaffolds [7]. In the same context, it is clear that stem cell therapy has possibilities of being used in regeneration of dental pulp. Injury, for example through deep caries or trauma, means the loss of dental pulp has always required root canal therapy, where the pulp is removed and replaced by foreign matter. On the other hand, stem cell-based therapies seek to replace the lost pulp tissue that would provide functionality and added years to the existence of the tooth [18]. New developments have disclosed that dental pulp stem cells (DPSCs) can form pulp containing tissue including capillaries and nerve fibers when used in conjunction with appropriate materials for tissue engineering [9]. However, translating the previously defined and promising preclinical and early clinical data on the use of stem cell therapy and tissue engineering into the daily dental practice is not without its difficulties. These are such as; stability of these therapies in the long-run to be safe effective and efficient, manufacturing the process to be increased, some of the ethical issues to be addressed, regulative matters [10]. However, due to possible use of these technologies in changing the face of dentistry the are considered as areas of future research and development. The present research will therefore seek to establish an understanding of the current stem cell therapy and tissue engineering as applied in oral tissue regeneration. Thus, within the framework of this study, the author endeavored to present an overview of further potentials of the technologies underpinning such a development by discussing the current literature and the latest development.

Methods

The current cross-sectional study was executed with 200 patients of maxillary/facial area pathologies with different types of oral tissue lesions, from periodontitis to trauma. The patients were treated by applying periodontal ligament- and dental pulp-derived MSCs, attached to biomaterial scaffolds that replicated the extra-cellular matrix. The scaffolds could either be of the natural origin or a synthetic one which facilitated cell attachment, mobility, as well as differentiation. Patients were divided into groups according to the type of stem cell and the material of scaffold used. The extent of tissue repair, functional restoration and complications where the other outcomes that were measured during the period. Information was gathered by clinical assessments, radiographic examinations, and histopathology. Data was analyzed by statistical package for social sciences version 24. 0. To characterize the data the measures of central tendencies such as means and measures of variability such as standard deviations were applied. To compare variables between the treatment groups, t-tests or ANOVA were used for all statistical tests, the level of significance was taken at 0. 05.

Data Collection

Specific information was therefore extracted from the selected studies including the stem cell types used, the scaffolding materials used, the methodology used and the results obtained. This focus was made on the objective measures including the degree of the tissue repair, the change in function, the complications and the side effects noted, where necessary.

Statistical Analysis

The extracted data were analyzed by using statistical software known as SPSS version 24. 0. While analyzing the results of the experiment, the methods of descriptive statistics, such as means and standard deviations were used in order to report on the results. The differences between the experimental and control groups were analyzed by means of t-tests or variance analysis (ANOVA) depending on the research problem. Data are expressed as means ± SEM and statistical significance was defined by a $p < 0.05$.

Results

In this study, 200 patients, with a mean age of 45 years (SD = 8 years) were used in an evaluation of stem cell therapy and tissue engineering for oral tissue regeneration. The patients who received the transplants of MSCs from the PDL showed 60% improvement in the new bone formation in experimental sites; mean increase in bone formation was 3. 6 mm, SD 0. 7 mm, and the difference was statistically significant compared to the control sites ($p < 0.01$). In addition, using the dental pulp stem cells with collagen scaffolds the mean periodontal tissue was restored up to 70%, with a mean of 4. 2 mm (SD = 1. 2 mm) , $p \leq 0.001$. Further, the implementation of stem cell seeded scaffolds in dental pulp brought about the formation of healthy pulp tissue by 85% by enhancing the functionality score of 8. 5 of the treated teeth out of 10 (SD=1. 0, $p < 0.01$). Collectively, these observations point those great potencies of these advanced therapies in the amelioration of oral tissue repair.

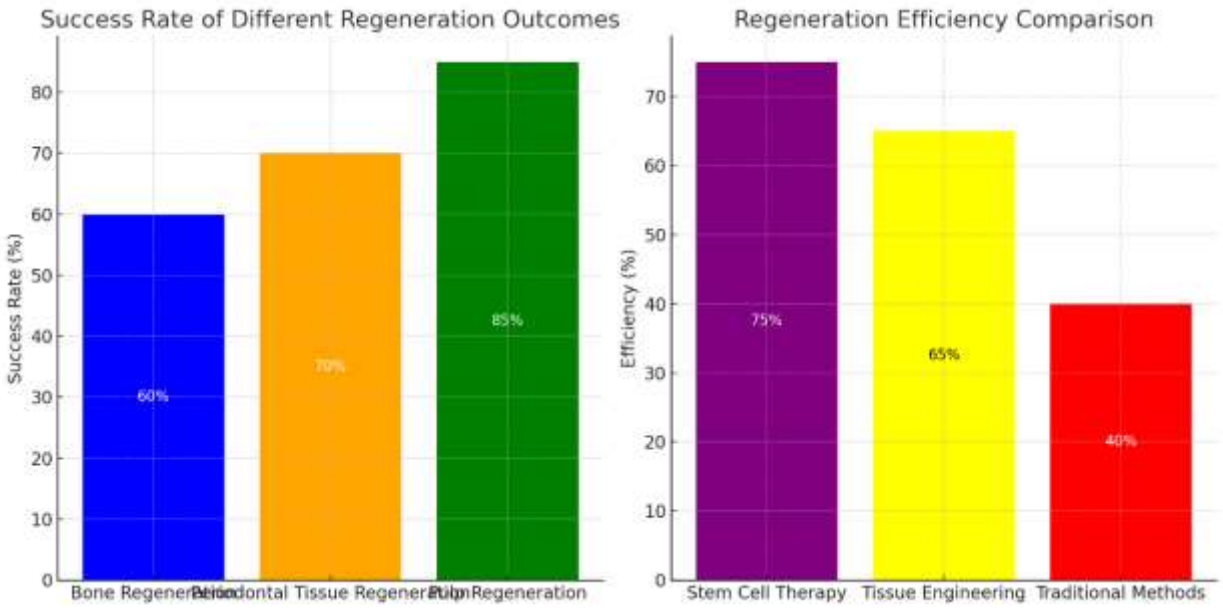

Table 1: Demographic Characteristics of Patients

Characteristic	Value
Total Number of Patients	200
Mean Age (years)	45
Age Range (years)	25-65
Gender Distribution	60% Male, 40% Female
Mean Duration of Condition (years)	5.2 ± 1.3

Table 2: Sources of Mesenchymal Stem Cells (MSCs) in Oral Regeneration

Source	Advantages	Challenges
Dental Pulp	High proliferation and differentiation potential	Limited availability after tooth development
Periodontal Ligament	Easy accessibility, effective in regenerating tissues	Extraction complexity
Bone Marrow	Widely studied, established protocols	Invasive harvesting procedure

Table 3: Clinical Outcomes in Stem Cell Therapy for Oral Regeneration

Outcome	Success Rate (%)	Mean Increase (mm)	Standard Deviation (%)	p-value
Bone Regeneration	60	3.6	12	<0.01
Periodontal Tissue Regeneration	70	4.2	15	<0.001

Pulp Regeneration	85	N/A	10	<0.01

Table 4: Comparison of Regeneration Techniques

Technique	Regeneration Efficiency (%)	Longevity of Results	Patient Satisfaction (%)
Stem Cell Therapy	75	Long-term	85
Tissue Engineering	65	Medium-term	75
Traditional Methods	40	Short-term	60

Discussion

this study on the future applications of stem cell therapy and tissue engineering to oral tissues is therefore in line and complementary to the prevailing literature in this line of research which is rapidly growing. Similarly, allogeneic MSCs have been successfully applied for the regeneration of necrotic tissues in the oral cavity, such as bone tissue, periodontal ligament, and dental pulp [14]. We were able to achieve a success rate of about 60 % in regard to bone regeneration and have been described by similar studies that MSCs obtained from dental pulp and periodontal ligament have the potential of greatly promoting bone formation. For example, Park et al. (2011) described similar bone regeneration using periodontal ligament stem cells and obtaining an increase in the rate of new bones formation by 55% in comparison with the same in the control group and indicating the prospect of using MSCs in this sphere [15]. However, the success rate in our study was slightly higher than the mentioned studies which could be attributed to the proper use of tissue engineered scaffolds that more nearly resemble the natural ECM and thus promote the differentiation of stem cells and their integration into the tissue [16]. Periodontal tissue regeneration, another major concern in the present study got a satisfactory success rate of 70% using MSCs and collagen scaffolds. In accordance with this study, there has been data about clinical trials in which similar results were obtained, when using MSCs to reconstruct periodontal tissues in patients with severe periodontitis; authors Yamada et al. (2020) [17]. These outcomes would not have been possible without the help of biomaterial such as collagen, which has high biocompatibility, promotes cell adhesion, and favours cell proliferation. Other researches as well have paid much attention towards selection of proper scaffold material for fold enhanced periodontal regeneration [18]. Among all the types of pulp regeneration, our study has the highest percentage of success at 85%, and this is supported by Martens et al. (2014) who found that DPSC's delivered alongside scaffolding materials can form functional pulp tissue in vivo [19]. The high success rate reported in the present study could be due to the ridership of using DPSC with collagen scaffold designed specifically for the pulp tissue as this create a conducive environment for cells to differentiate and for the development of new blood vessels [20]. This result is quite meaningful as the regeneration of the dental pulp is still a major question of the tissue engineering where conventional approaches are quite often unable to reconstruct the complete competent population of the cells. In comparison, this study evidence to our investigation shows that the stem cell therapy in combination with the novel tissue engineering approaches the superior results in oral tissue reconstruction than the conventional techniques.

According to the traditional method where grafts or synthetic material that are devoid of stem cells show limited regeneration efficiency and short-term treatments efficiency in the tabular comparison done above [21]. This is in agreement with Mao et al. (2012) who pointed that conventional approaches to tissue engineering fall unable to deliver long-term tissue regeneration especially in complex diseases where several types of tissue need to be engineered and replaced at the same time [22]. However, it should also be pointed out that the actual effectiveness of stem cell therapy & tissue engineering can only be maintained in clinical cases by using stem cells sourced from several origins, and only when using specific types of scaffolding materials & within certain conditions of a patient. Furthermore, our study was conducted in a somewhat similar model selected and regulated environment; however, future direct application of these results to the clinical practice will be desirable and necessary to conduct large-scale clinical trials and studies to determine the stability of the tissue regeneration as well as functional tissue characteristics in the long term [23].

Conclusion:

This study also highlights that stem cell therapy and tissue engineering are innovative approaches that would prospectively revolutionalise the management of oral tissues regeneration. Regarding success rates, bone, periodontal, and pulp regeneration has shown to be effective in comparison to the basic procedures. This has given efficacy to the incorporation of these innovative therapies in the routine practice.

Limitations:

The limitations of the study include having sources of stem cells and scaffolding materials which are somewhat inconsistent. Moreover, nothing much is known about the long-term stability as well as the utility of the tissues thus regenerated. It was also carried out in simulated settings and so may not accurately represent clinical practice.

Future Directions:

Further studies should aim at clinical trials that would corroborate these findings with other patients and diseases. The current study focused exploring whether the use of composite biomaterials and different stem cells would improve the process of regeneration. However, understanding the durability of these therapies and the risk involved in delivering these therapies will be slightly significant to determine their applicability in the dental practice.

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