

Biomimetic And Regenerative Considerations In Endodontics: A Review

Abstract:

Biomimetics, literally means to mimic or copy what is life-like from nature. Biomimetics provides a new technique for improving our understanding of natural designs and functions, as well as new promising paths for mimicking natural processes. The first part of biomimetic dentistry is the restoration of destroyed or degenerated dental tissue, resulting in the full restoration of both functionality and appearance to the tooth. Additionally, the material utilized can repair, reproduce, or simulate missing dental tissue. This concept is very wide and has been applied in dental materials, for the regeneration of lost dental tissue from the stem cells. Regeneration approach is a form of biomimetics that promotes for the restoration of damaged tissue using tissue technology rather than the conventional method. The purpose of this review is to increase our understanding of biomimetics and regeneration factors related to lost tooth tissue in the field of endodontics

Key-words: Biomimetic, regeneration, mimic, endodontics, tissue engineering, dental tissue

Introduction:

Biomimetics (from bios, means being alive, and mimesis, means to copy) is the study of the natural finest advances followed by replicating those patterns to build newer techniques.[1] Biomimetics is a novel branch of science which integrates data gathered through the study of living things and their roles with mathematics, physics, and chemical science to develop concepts that are essential to the development of unique artificial substances and organs.[2,3] Biomimetics offers an innovative approach for turning our understanding of biological functions and structures into novel methods for mimicking biologically based procedures. Practitioners in dentistry can use biomimetic procedures to repair, reproduce, or closely imitate the missing dental tissue with the aim to reestablish its functionality. Overall, biomimetics covers multiple issues by developing new concepts based on natural phenomena and applying these to different technologies. Thus, there can be favorable outcomes in dentistry from the application of this innovative and conservative biomimetic therapeutic approach.

Regeneration is referred to as the process by which degraded tissue is reconstituted by similar tissue, as well as the rehabilitation of physiological functions.[4,5]

In addition, Regenerative endodontics is defined as “biologically based procedures designed to replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex”.[6]

The word regenerative endodontic procedures (REPs) is nowadays extensively used, and it includes to every therapies that attempt to achieve systematic reconstruction of the tooth pulp, as well as future therapies that have not yet been developed in the endodontic practices.[7]

The goal of such regenerative therapies is to replacement of lost cells without claiming that this recovery is a full replication of the previously missing tissues. It is an innovative approach that aims for the entire rehabilitation of

¹VIVEK THAKUR, ²VISHAL SHARMA

³ANSHU MINOCHA

¹⁻³Department of Conservative Dentistry and Endodontics.

Address for Correspondence: Dr. Vivek Thakur
Government Dental College and Hospital,
Shimla (H.P)-171001
E-mail : vtvivekthakur421@gmail.com

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defective tissue, based on tissue engineering as opposed to traditional approach. These biologically based techniques continue to be crucial in the practice of endodontics and have tremendous potential for future advancements.

The overall goal, however, involves complete rejuvenation of pulp-dentin complex identical to original missing tissues. Though these tissues do not represent real pulp tissues, they are the host's innate vital tissues. The inherent immunity inside a canal, which is suppressed following traditional root canal therapy that can be restored following regenerative procedure, may have an ability to decrease recurrence of infections. Additionally, regenerated tissues might be structurally immune to breakage compared to traditionally root canal treatment.[8]

History and Objectives:

This broad recent field of biomimetics has a long history. The word "biomimetic" was initially coined in the 1950s by Ottoschmit. Dental healthcare providers may enhance the management of dental ailments and deformities by employing biomimetic treatment methods that bring it nearer to natural living things along with functions. There are two important components to which the term "biomimetic" is employed: the recreation of lost biological dental tissues and the materials used can regenerate, replicate the biological effect of lost dental tissue closely. Therefore, the primary goals of biomimetic dentistry consist of repair dental structures and replace missing dental tissues using biologically based procedures.[9]

Regenerative endodontics has been related with revascularization treatments for more than 50 years.[10] Nygaard- Ostby found that the clot of blood in root canals caused by inducing of blood was related to a slow conversion of tissue with granulation into fibrous connective tissue.[11] Ten years later, Nygaard-Ostby and Hjortdal noticed the formation of cellular cementum in disinfected canal as bleeding is caused by overinstrumentation.[12] Iwaya et al. discovered a case of an infectious necrotic tooth with apical periodontitis in 2001, which showed that the maturation of root and the canal walls were thickened through a process called "revascularization".[13] Furthermore, these revascularization/regenerative procedures eradicated clinical signs and symptoms with reduction of apical periodontitis in infected necrotic teeth. As a result, the main purpose of REPs

is comparable to that of traditional endodontic treatment. Conventional root canal therapy and REPs differ mainly in that the former fills the cleaned canals with foreign materials that are biologically compatible, while the latter fills the canals with the host's own living tissue.

Biomimetic Considerations In Endodontics:

The practice of endodontics has traditionally relied on tactile sensation with endodontic files rather than visibility. As instruments were inadvertently pushed inside root canal, the only guide was tactile sensation. When combined with radiography and apex locators, this conventional approach has achieved extraordinary results. However, there is a considerable failure percentage, particularly over lengthy periods of time, which is leading contemporary dentistry to forcefully extract the natural teeth in support of implants. Clinical failures are often a potent motivation for modification of management strategy. The idea that the canals are in a straight line, terminate at the radiographic apex, and have a spherical circumference was a major error during the period of traditional endodontics. Usually canals exhibit curve that goes eccentrically and falls short of the radiographic apex.[14]

Biomimetics is a form of treatment whose main objective is to preserve as much biological tissues as possible as well as mimicking the components of the human body. The objective of endo-restorative treatment should be to restore the pulp space that existed when the tooth was immature. Because of the unstructured and varying deposition pattern, it might be claimed that the secondary dentin made offers more rigidity. The remarkable strength of young teeth with large pulp chambers and canal pulp spaces confirms this theory. If only a small conservative rounded access that does not damage primary dentin allows instruments to penetrate the considerable complicated root canal architecture, then rounded access is appropriate for intervention. The actuality of ovoid roots appears to contradict this method of access preparation. The standard strategy nowadays is to create a big traditional rounded access, which results in the removing of primary dentin from a slender and narrower section of the root. Although it offers accessibility to more sophisticated root canal network which takes place till apical end, this does not meet the final objectives of biomimetic dentistry.[14]

Regenerative Considerations In Endodontics:

Because the final outcomes of regenerative endodontic procedures are so different from conventional root canal treatment; as a result, it has generated a great deal of curiosity and focus in the domain of endodontics recently. Although the main objective of regenerative therapy is the remission of

apical periodontitis, like conventional root canal treatment, there are still several differences in their basic principles and associated techniques. The pulp-dentin complex that REPs form in the root canal by bleeding induction can affect the three elements of tissue engineering— growth factors, scaffolds and stem cells. [15-17]

The major goal of endodontic practice continued as to ensure the survival of the natural teeth. Whenever the pulp needs to be removed because to disease or for restoration purposes, then it is substituted by synthetic type filling materials. Endodontists are willing to use natural resources instead of artificial ones since tissue engineering has become widespread in the medical and dental fields.[18] The specialty of endodontics uses tissue engineering for a wide range of purposes, including the regeneration of the pulp-dentin complex. Many research investigations have drawn attention to limitations of traditional root canal therapy that it is a significant role in change of tooth color and fracture.[19-21]

Because of previous disease, root canal treatment and restoration, a tooth typically experiences significant structural loss. According to some studies, the aforementioned tooth has loss of protective system of proprioception.[22,23] As a result, the preservation of potential proprioceptive defensive mechanisms in the pulp and the development of nerve function in the rejuvenated pulp tissue will serve as an alert system during tissue damage and shield the pulp from additional harm or the possibility of tooth breakage.[23,24].

Furthermore, the benefits of REPs include improved immune defense mechanism, active pulp-dentin complex, and homeostasis of tooth.

REPs continue to exhibit favorable outcomes, making them a feasible therapeutic option for necrotic immature teeth.[25-29] With the intention of regenerating pulp tissues, REPs have recently been employed for the treatment of necrotic mature teeth with successful outcomes.[30-32] Even if they are not true pulp tissue, those tissues are the host's innate vital tissues, and these are inherited with immunological defensive systems to save themselves from reinfections.[33-37]

Regenerative endodontic treatment holds promise as a feasible acceptable treatment choice with a high success rate in necrotic mature teeth with apical periodontitis, as it resolved clinical signs and symptoms, healing of the periapical lesion, and restored tooth sensibility. [38,39]

Relationship Between Biomimetic And Regenerative Endodontics:

In endodontics, biologically based approaches have long been significant and provide immense potential for future advancements. Regenerative endodontic treatments using tissue engineering are the foundation of a biomimetic approach to treating tooth structure, which is a novel field for dental professionals. In other words, the study of biological tissues through an understanding of biomimetic concept can provide valuable ideas for tissue engineering. Tissue engineering as a field has already taken its small steps. As a result of this experience, biomimetics is gradually entering the cellular or molecular level. A biomimetic approach is suggested to create an artificial three dimensional microenvironment that facilitates the understanding of the processes regulating stem cell activities for the regeneration.

Stem cells live in niches that provide the necessary microenvironment for the cells to maintain their stem-like, undifferentiated state.[40] These niches work in combination with bioactive substances including matrix molecules, cytokines, and growth factors to preserve stem cells at the highest possible level of differentiation. Furthermore, regenerative endodontic procedures in both immature and mature teeth may be supported by the creation of biomimetic microenvironments, which capitalize the tooth's inherent capacity for self-regeneration that are based on the knowledge of its intrinsic biological characteristics.[41] Ultimately, this kind of microenvironment will help the study of stem cells to be successfully applied to the development of the tissue regeneration treatments.

Role of Biomimetic Materials in Regenerative Endodontics:

The term "biomimetic material" refers to a substance created using a biomimetic technology that mimics the natural process present in biological system.[42] Biomimetic materials such as biodentine, bioaggregate and scaffolds like blood clot, platelet rich plasma (PRP) and platelet rich fibrin (PRF) play very significant role in regenerative endodontic therapies. The study showed that biodentine involved in early odontoblastic differentiation, TGF- β 1 secretions and initiation of mineralization and thus induce reparative dentin synthesis.[43]

Regenerative endodontic procedures (REPs) typically involves lacerating the periapical tissues to induce intracanal blood clot formation or the application of PRF or PRP after the canal has been disinfected and the symptoms have subsided. According to a key study, the induced-bleeding step in

regenerative techniques causes a significant number of undifferentiated stem cells to accumulate in the canal.[16] Based on bioengineering concepts, modern regenerative endodontics involves the interactions of growth factors, scaffolds and stem cells.[44]

The purpose of using biomaterials as scaffolds is to build a structural foundation that will support cells while they regenerate tissue. The goal of selecting a particular biomimetic material for a scaffold is to create a specific microenvironment that can replicate cell-cell, cell-extracellular matrix (ECM) and cell-soluble factor interaction in pulp-dentin complex. A suitable scaffold for the regeneration of pulp-dentin should support the stem cells of interest during their proliferation, migration, 3-D spatial arrangement, and differentiation into odontogenic, neurogenic, and vasculogenic lineages. Additionally, in order to avoid any negative reaction by the host tissues, the biocompatibility of the material is crucial.

A hydrogel, a three-dimensional (3D) structure containing pores, or a combination of both could be used as the scaffold. Furthermore, hydrogels are simple to use and noninvasively place into root canal systems using a syringe. According to a study, the hydrogel may encourage pulp regeneration by offering a surface on which cells can differentiate and proliferate into well-organized tissue.[45] Collagen and chitosan are natural scaffold and utilized for variety of tissue regeneration applications since they are biocompatible and degraded by naturally occurring enzymes.[46,47] Furthermore, biomimetic scaffolds composed of "natural" materials are becoming more and more popular as an alternative to artificial polymer scaffolds, which are not as mechanically robust as natural ones.

Conclusion:

Using a biomimetic approach, the field of regenerative endodontics holds great potential for the future. There is a whole investigations trying to regenerate the pulp-dentin complex, with the intent that the pulp can heal itself, then clinicians might be able to not only replace the foreign materials currently used in conventional endodontic approaches, but also significantly improve the outcomes of endodontic treatment. Therefore, a superior prognosis, great biocompatibility, and high success rate can be ensured by regeneration of the degenerated tissue instead of replacement during therapy.

Furthermore, the ultimate objective of biomimetic and regenerative research is to enable dental professionals to restore missing tissue in a way that is more natural and

compatible with the body. In the field of endodontics, these advancements have long been significant and present an abundance of opportunities for further research and innovation.

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