Bioadhesive Biomaterials for Medical Application

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This entry deliberates about the importance of polymer based bioadhesive biomaterial's medical application in healthcare and redefining healthcare management. Nowadays application of bioadhesion in health sector is one of the great interest for various researchers, due to its recent advances in their formulation development. Actually, this area of study is considered as an active multidisciplinary research approach, where engineers, scientists—including chemists, physicists, biologists, and medical experts—materials' producers, and manufacturers combine their knowledge in order to provide a better healthcare. Moreover, while discussing about the implications of value-based healthcare, it is necessary to mention that health comprises three main domains namely: physical, mental, and social health that prioritized not only the quality healthcare, but it also enables to measure the outcomes of medical interventions. In addition, this conceptual article provides an understanding about the consequences of natural or synthetic polymer based bioadhesion of biomaterials and its significance for redefining healthcare management as a novel approach. Furthermore, research assumptions highlights that the quality healthcare concept has recently become a burning topic where, healthcare service providers, private research institutes, government authorities, public service boards, associations and academics took initiative to restructure the health care system to create value for patients and increase their satisfaction, and lead ultimately to a healthier society.

bioadhesion biomaterials biomedical application healthcare system management innovation polymer based bioadhesive

1. Introduction

Currently, in the 21st century, healthcare management plays an important role in focusing and aligning the myriad continuous improvements that optimize the application of bioadhesion as related to innovative biomaterials' medical use. This article intends to reveal the importance of bioadhesive biomaterials' application in the healthcare system. Nowadays, the application of bioadhesion is one of greatest interests for various researchers who intend to develop new biomaterials, therapies and technological possibilities, such as biomedical application. Accordingly, progressive innovation in the bioadhesion of biomaterials has trended sharply upward, and is expected to double by 2020, especially with a focus on delivering quality healthcare. Although redefining health, the World Health Organization (WHO) defined 'health' as a state of complete physical, mental and social wellbeing that not only considers the illness, but prioritizes the concept of value-based healthcare [1]. On the other hand, from the functional perspective, bioadhesives can be considered as an identical material, which is biological in nature and holds together for extended periods of time by interfacial forces. Essentially, it is an area of active multidisciplinary

research approach, wherein engineers, scientists (including chemists, physicists, biologists, and medical experts (supportive medical), materials producers, and manufacturers combine their knowledge [2]. Finally, from the practical point of view, this article proposes some research assumptions, which state that the bioadhesion of biomaterials for redefining healthcare management is not a new concept. Its implementation has been used for several years for medical applications, such as dentistry and orthopedics, and it is now entering new fields, for example, tissue sealing and directed drug delivery systems. In addition, the said issues and solutions affect and involve healthcare delivery organizations, health plans and employers, i.e., healthcare service providers, private research institutes, government authorities and public service boards, research institutes, associations and academics. The outcome will be, in the long-term, to restructure the healthcare system, which will not only create value for patients and increase satisfaction, but it will also improve the health effects through enabling new efficiencies and lowering costs.

1.1. Notion of Biomaterials

Regarding the notion of “biomaterials”, it is necessary to mention that there are two significant topics that are inter-related with the concept of the word biomaterial. The first conceptual meaning of biomaterial deals with the term ‘bio’, which exemplifies, as a way of filling in the gaps where the question arises, whether we are discussing the process of taking out of life or putting into life. The second term, “material”, has a broader sense, which indicates a substance. Now the question arises of how this material can enable us to keep our life more flexible. Research shows that from the healthcare benefit point of view, several scholars have made an effort to define the term “biomaterials” and its application as well as utility in our day-to-day life. In medical science, research has shown that it has ample potential to keep our life more flexible, in that it will easily enable us to respond to altered circumstances. Although, biomaterials’ presentation in medical science did not get that recognition until the Consensus Conference on Definitions in Biomaterials Science, held in 1987. According to the European Society for Biomaterials, earlier, the term biomaterials and its medical application were not so profoundly known in the medical science, though its application was already existing [3], as the definition is a result of considered debate, which definitely has some reliability from a healthcare point of view. On the other hand, this conceptualization of biomaterials concludes that a biomaterial is “a non-viable material and its application in a medical device, is envisioned to interrelate with the biological systems” [4].

1.2. Overview of Bioadhesion

Bioadhesion may be defined as the binding of a natural or synthetic polymer or biological-origin adhesive to a biological substrate. When the substrate is a mucus layer, the term is known as mucoadhesion [5]. On the other hand, while referring to the application of bioadhesion in broad terms, it is necessary to mention that the terminology “bioadhesion” itself represents an extensively differentiated phenomena, as it covers the adhesive properties of both the synthetic components as well as the natural surfaces (such as cells). Furthermore, research shows that bioadhesion could also refer to the usage of bioadhesives in order to link the two surfaces together, especially in drug delivery, dental and surgical applications [6]. As such, the significance of bioadhesive biomaterial

application has emerged and been recognized due to its consequences for the specific development of new biomaterials, therapies and technological products for redefining the healthcare sector.

2. Bioadhesion of Biomaterials

While discussing the significance of the bioadhesion of biomaterials, it is mandatory to highlight that in the contemporary world, healthcare is a fundamental issue in translational research, especially when it is innovative, as well as the fact that the bioadhesion of biomaterials application is being used in healthcare in order to fight against life-threatening diseases. In addition, over the past two decades, innovative biomaterials applications have been viewed as a significant issue in translational research in the field of regenerative medicine, where biomaterials have been extensively applied in numerous medical devices for the benefit of healthcare. In this regard, it is necessary to state that the study of biomaterials is essentially associated with the study of biocompatible materials, especially for biomedical applications, which encompasses not only the synthetic materials, such as metals, polymers, ceramics and composites, but also includes biological materials, for example proteins, cells and tissues. The below-mentioned Figure 1 shows examples of the bioadhesion of biomaterials.

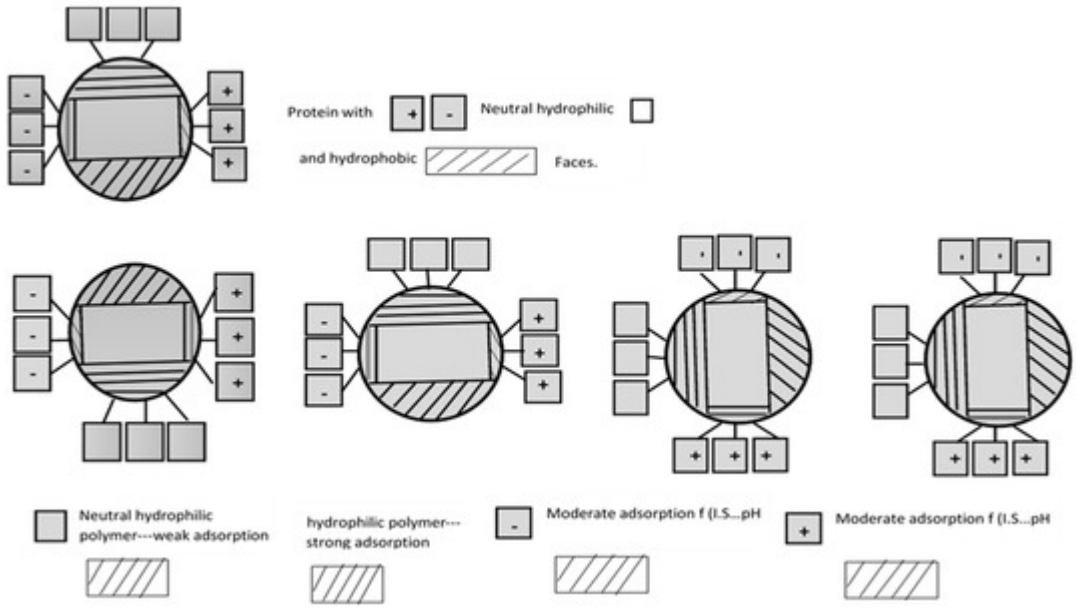

Figure 1. Bioadhesion of biomaterials (based on the idea from the *Bioadhesion of Biomaterials*, and Medical Devices, Springer Book [7]).

On the other hand, the term bioadhesion refers to the situation wherein natural and synthetic materials stick to each other, and especially to biological surfaces. Henceforth, the application of bioadhesive polymers in healthcare emerges, specifically with the use of medical devices for the effects on the biological exterior and crossing point. In this review article, the authors attempt to prove that, from the healthcare point of view, bioadhesion's presentation is advantageous. Considering the grafting of medical devices in the human body, it is necessary to remember that though this embedding procedure is a very useful and important aspect of healthcare, we cannot ignore the probability of high risks due to the interface for microorganisms. As implantable medical devices are the idyllic

location for the growth of microbes, infections are triggered quickly by bacteria that mainly originate in the body itself. Consequently, some phases effect the bioadhesion of implantable medical devices, including surface topography, chemical interaction, mechanical interaction and physiological interactions.

3. Bioadhesive Biomaterials' Biomedical Applications

Bioadhesives are generally used in wound healing and hemostasis, and their use is incipient in other biomedical applications such as tissue engineering and regeneration. The incoherence between the tissue and the biomaterial is connected using the tissue adhesives in tissue regeneration [8].

Furthermore, while discussing the practical applications of bioadhesive biomaterial research in medical aspects, it is necessary to mention that over the past decade, a growing amount of attention has been paid to bone tissue engineering for research and development in bioadhesive biomaterials' biomedical applications, and resource management, around the world to meet the societal challenges.

Accordingly, the progressive innovation in bioadhesive biomaterials has trended sharply upward, and is expected to double by 2020, especially with a focus on the application of bone tissue engineering. As such, to provide a quality healthcare service, microbially derived polysaccharides (MPs) are demanding, as they are sued for novel, multi-informant, operationally deployable, commercially exploitable and natural-origin raw materials for the production of commercially applicable products in the form of hydrogel and bio composites. These MPs are of bacterial origin (bacterial cellulose (*Acetobacter xylinum*); chitosan (*Aspergillus niger*) and Levan (*Microbacterium laevaniformans*)). Beside the applications of MP and MP-based bio-composites in the health and nano-biotechnology sectors (cell to-cell interactions, biofilm formation, and cell protection against environmental extremes), such polysaccharides are also used as thickeners, bioadhesives, stabilizers, probiotics, and gelling agents in the food and cosmetic industries, and as emulsifier, biosorbents and bioflocculants in the environmental sector.

Concerning the application of bacterial cellulose (BC), it is necessary to indicate that the application of BC has been observed in a broad spectrum, especially in different areas, such as the newspaper industry, electronics, and tissue engineering, due to its remarkable mechanical properties, conformability and porosity. This work has primarily focused on the issue of the biocompatibility of BC and BC nanocomposites and their biomedical aspects, such as surface modification for improving cell adhesion, and in vitro and in vivo studies that focus on the cellulose networks. In summation, the relevance of biocompatibility studies has also emphasized the development of BC-based biomaterials' medical applications in bone, skin and cardiovascular tissue engineering [9].

On the other hand, as regards the biological properties' influence on biomedical application, chitosan has many beneficial biomedical properties, such as biocompatibility, biodegradability, and no toxicity. Therefore, it has been observed that the biological activity of chitosan is closely related to its solubility. This also highlights the development and improvement of scaffolding, i.e., the support of biomaterials using a framework for regenerative medicine. Regarding biomaterials' medical applications, it is obligatory to remark that scaffolds are one of the

crucial factors for tissue engineering, such as scaffolds containing natural polymers that have recently been developed more quickly and have gained more popularity. These include chitosan, a copolymer derived from the alkaline deacetylation of chitin. In order to provide a quality healthcare nowadays, the expectations for the use of these types of scaffolds are increasing as the knowledge regarding their chemical and biological properties expands, and new biomedical applications are being investigated [10][11].

The protein-based adhesives materials are basically from animal sources which trigger an inflammatory response compared with human derived materials. Nowadays, various protein-based bioadhesive products are under development for clinical trials (phase III and phase IV), for example, as hemostatic sealants in cardiac surgery as vascular graft attachments, valve attachments, etc., drug delivery systems (as for example in the gastrointestinal tract, nasal delivery and ocular drug delivery), wound-healing dressings and military applications [8].

4. Implementation of Bioadhesive Biomaterials in Healthcare

In this contemporary age, bioadhesive biomaterials are considered as an innovative property oriented material that empower to build an intimate relationship with the living tissue. Currently, biomaterials are revolutionizing many aspects of preventive and therapeutic healthcare that plays an important role, especially, during the development of new medical devices, prostheses, tissue repair and replacement technologies, drug delivery systems and diagnostic techniques. Hence, due to advance biomaterials promising opportunities, presently the application of biomaterials in health sectors are the one of the main focus of major research efforts around the world. Research shows, that development in this field of research requires a multidisciplinary approach, where scientists interact with engineers, materials producers and manufacturers. On the other hand, it is necessary to mention that to face the recent challenges of healthcare management is often very demanding. Therefore, it has been observed that the required skills and resources are beyond the capabilities of a single organization, or even of a single country. Accordingly, collaborative research is thus becoming the key to achieving breakthrough results in order to bring leadership in the global marketplace [12]. “Bioadhesion of Biomaterials” covers the bioadhesion aspect of biomaterials as healthcare challenges via research and development of effective and low-cost. However, their application as medical devices were limited to the degradation [7].

From the healthcare perception point of view, biomaterials can be demarcated as a “materials that mainly clasp with some innovative properties that facilitate to emanate in immediate contact with the living tissue without eliciting any adverse immune rejection reactions.” These types of biomaterials are envisioned for usage in healthcare especially, for the purpose of diagnosis of disease and for the treatment or for the prevention of other diseases in human body or other animals. Additionally, it is essential to express that this condition is normally not dependent upon being metabolized for the achievement of any of its principal intended purposes or not. Equally, these devices and or any type of biomaterials are typically used for physical replacement of some hard or soft tissue, which has suffered any accidental damage or destruction through some pathological processes [13].

In relation to biomaterials application in healthcare, it is known that biomaterials usage for health purpose is not a new concept. Application of biomaterials in health issues started from a long period of time. Though, the noticeable

advancement of biomaterials application has been observed since 1940s but the substantial development has been detected over the past 25 years especially while applying therapeutic medical technologies and implant devices [13]. Furthermore, from the implementation of bioadhesive biomaterials application in healthcare, research shows that from the ancient periods, tissue adhesives and sealants application in healthcare have renovated a lot, especially in wound management and in traumatic and surgical injuries. For example, tissue adhesives and sealants application in healthcare is well-known to treat disorders of hemostasis, i.e. is the physiological process that stops bleeding at the site of an injury while maintaining the normal blood flow circulation within the body [14]. Instead, various biological-driven glues and synthetic adhesives are clinically utilized either for the betterment of health as an adjunct to conventional hemostats and wound closure techniques, such as suturing, or as a replacement purpose. As a result, it can be said that this way of bioadhesive biomaterials set-up in healthcare gradually improve the ability of effectively and quickly controlling bleeding. Consequently, it helps in reducing the risk of complications due to severe blood loss that act as an important implement of medical adhesive, which is a highly suitable tool for wound management [15].

5. Redefining Healthcare Management in Relation to Bioadhesive Biomaterials Medical Application

To address the conceptualization of ‘redefining healthcare management’, it is significant to discuss about the idea of re-emerging “value-based healthcare” for healthy societal development. Currently, this value-based healthcare impression enforces researchers, mainly who are keen in innovative bioadhesive biomaterials application in healthcare due to its recent development in their formulation. Where, engineers, scientists (i.e. chemists, physicists, biologists, and medical experts) materials’ producers, and manufacturers combine their knowledge to reconsider all the aspects of health care management in order to provide and maintain the good health of a population. According to the report of the Economist Intelligence Unit [98], value-based healthcare can be considered as the formation and operation of a quality health system that explicitly prioritizes on quality health products. In this regard, it is necessary to say that bioadhesive biomaterial applications in healthcare deliver quality health through integrated and technologically sophisticated heath care delivery system. Modern healthcare also has four main principles such as: (i) evidence-based, patients centred and inclusive cares, (ii) the community, continuous and coordinated, (iii) ethically sound and (iv) regulated healthcare system [16][17][18]. This review article intends to describe in Figure.3 the contemporary indulgent about the significances of bioadhesive biomaterials for biomedical applications in healthcare for redefining healthcare management as a novel approach.

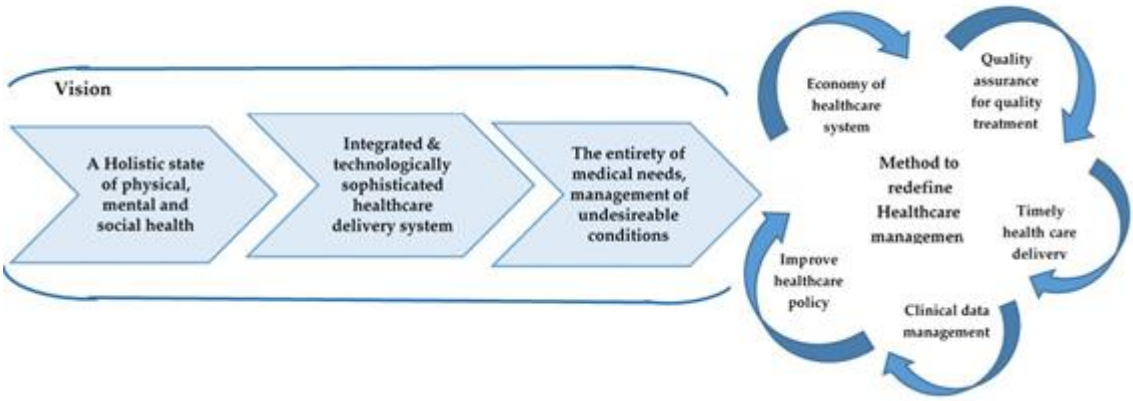

Figure 3. The Conceptual Approach of Redefining Healthcare Management.

Hence, the value-based healthcare concept, i.e. to redefine healthcare system particularly emphasized on proper health objective in order to increase the value. Research shows, that value is generated from health consequences which matter to the following three visions. The presented Figure.3 illustrate the conceptual approach of redefining healthcare that demonstrated the way to enhance quality healthcare as well as to maintain a programmatic approach, it is necessary to have a Holistic state of physical, mental and social health condition or environment; need integrated and technologically sophisticated healthcare delivery system to provide unique patient circumstances; and care all-inclusive patients medical needs, including critical and chronic disease prevention as well as management of undesirable conditions'[18].

However, to redefine healthcare, transformations requisite to be done by both health providers and patients as well through appropriate healthcare delivery, proper clinical data management by strengthening primary care, building integrated health systems, i.e., quality assurance for quality treatment and implementing appropriate health payment schemes, i.e. economy of healthcare system that will promote the value and reduce moral hazards, enabling health information technology, and creating a policy appropriate for healthy community [1].

The conceptual framework of redefining healthcare management in relation to bioadhesive biomaterials was developed based on the idea of care management conceptual model [17]. In this research, the main highlighted point is to highlight the importance of innovative bioadhesive biomaterials medical application to redefine all the aspects of health practice. This review article intended to raise the awareness of healthcare service providers, private research institutes, government authorities, public service boards, associations and academic initiatives to restructure the health care system that will not only create value for patients and increase satisfaction, but it will also create a healthier society. Therefore, based on the idea of care management conceptual model this study develops a thematic diagram to define the linkage of redefining healthcare management in relation to bioadhesives for medical applications. Figure 4 represents this connection between the healthcare service providers, patients, and members, i.e. (research institutions, associations & academics). This schematic diagram demonstrates the critical element of the patient to this connection that influencing medical issue factors. By including the patient

element in the framework, this study considers the potential influence of patient characteristics, i.e. effective self-care and the relationships of patients with clinics / clinicians and community resources, i.e. high quality clinical care.

To define the relation to bioadhesive biomaterials medical application, it is necessary to denote that biomaterials are widely used in many kinds of medical devices. The biomaterials used can be protein, metal, polymer, ceramic or composites. Similarly, bio adhesion will be occurred when the medical device contact to biological surface. Figure 3 demonstrates that bacterial cellulose, levan, and chitosan have excellent and praise-worthy applications in medical field (already explained in earlier part of this article).

But also protein-based adhesives play a vital role especially when using biological adhesives for medical applications. Remarkable thing is that since primeval eras, tissue adhesives and sealant applications in healthcare have renovated a lot, particularly in wound management and in traumatic and surgical injuries. Thus, based on our previous discussion, it can be said that the process of placing quality clinical care as well as patients' effective self-care has a close connection that redefines the existing health care in order to avoid further risks and can receive needed preventive services. A linkage, therefore, represents the combined influence of all seven basic factors (health policies, providers, patients, members, bioadhesive biomaterials medical application, quality clinical care patients' self-care) and their levels of collaboration that enable to achieve expected outcome, i.e. economic value-based healthcare for delivery of a preventive service.

Figure 4. Thematic diagram of redefining healthcare management in relation to bioadhesive biomaterials (based on the idea of care management conceptual model) [17].

6. Conclusion

Finally, it can be said that this review article delivers an understanding about the consequences of bioadhesion of biomaterials application and its implication for redefining healthcare management as a novel approach. Even though some research has been performed in order to describe the polysaccharides based adhesives application at a micro level or at Nano level which, has been done for the preparation of molecularly smooth films for healthcare resolution. Hence, it is necessary to continue this research in this area in order to obtain a better understanding about the adhesive interactions beyond hydrogen bonding including mechanical interlocking, interpenetrating networks, and covalent linkages on a fundamental level to improve interfacial properties with thermoplastics, thermosets and biopolymers. Relating to this issue of bioadhesive biomaterials application in the healthcare system, this study exposes the presentation of progressive innovation in bioadhesion of biomaterials. Meanwhile, today innovative biomaterial applications tend sharply upward and are expected to double by 2020, especially with a focus on delivering quality healthcare. While redefining health, it is necessary in order to mention that health consists of three main domains namely, physical, mental, and social health that prioritized with value-based healthcare concept.

The analyses revealed some important research assumptions that were predictive of both healthcare management and innovative biomaterials application which states that bioadhesion of biomaterials for redefining healthcare management is not a new concept. Its implementation has been used for several years for medical applications such as dentistry and orthopedics' and is now entering new fields, for example, tissue sealing and directed drug delivery systems. From the practical implication point of view, the results provide an important insight into the notion of involving healthcare delivery organizations, i.e. (health care service provider) in medical science for resource management that facilitates to cope up with the socio-economic challenges of Horizon 2020. As an outcome, it is assumed that government authorities and public service boards, research institutes, associations and academics to restructure health care system that will not only create value for patients and increase satisfaction, but it will also improve health outcomes through enabling new efficiencies and lowering costs.

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