International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

Review Article

Applications of chitosan in dentistry: A review

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ABSTRACT:
D-glucosamine, derived from the deacetylation of chitin present in the shells of marine crustaceans, is repeatedly converted into a macromolecule known as chitosan (in particular from crabs and prawns). Chitosan is a natural polysaccharide with confirmed antibacterial properties that is biodegradable and non-toxic. Among the many advantages of chitosan and its derivatives are their excellent biocompatibility, non-toxicity to humans, biodegradability, reactivity of the deacetylated amino groups, selective permeability, polyelectrolyte action, antimicrobial activity, ability to form gel, film, and sponge, absorptive capacity, anti-inflammatory properties, and wound healing properties. 4,5. One of chitosan's most notable qualities is its high bioactivity, which makes it a very interesting material to use in the development of new biomaterials for application in the field of dentistry. This review's objective was to investigate chitosan's potential use in dentistry.
Keywords: Chitosan; Biodegrability; Natural polysaccharide,dentistry,regeneration

Received: 19 November, 2022 Accepted: 18 December, 2022

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This article may be cited as: Kaur H, Bharti S. Applications of chitosan in dentistry: A review. Int J Res Health Allied Sci 2023; 9(3):10-14.

INTRODUCTION

A macromolecule called chitosan is created when D-glucosamine, which comes from the deacetylation of chitin found in the shells of marine crustaceans, is repeated (in particular from crabs and prawns). It is a fibre that is indigestible and chemically comparable to cellulose. A natural polysaccharide with biodegradable, non-toxic, and tested antibacterial characteristics is chitosan[1,2]. Although some publications only refer to it as chitosan after it has undergone 70% deacetylation, the common word is used to refer to chitin that has reached around 50% deacetylation. Chitosan is currently a commonly utilised substance since it can be generated from renewable sources, possesses antibacterial qualities, is biocompatible, and has no harmful effects. Chitosan usage in several dental applications has been studied.[3]
Excellent biocompatibility, non-toxicity to humans, biodegradability, reactivity of the deacetylated amino groups, selective permeability, polyelectrolyte action, antimicrobial activity, ability to form gel, film, and sponge, absorptive capacity, anti-inflammatory properties, and wound healing properties are just a few of the benefits of chitosan and its derivatives[4,5]. High bioactivity is one of chitosan's most significant characteristics, which makes it a very fascinating material to use in the creation of new biomaterials for use in the field of dentistry[5].

HISTORY

In 1811, Braconnot named the chitin he extracted from mushrooms fongine; Odier later changed the name to chitin. When Rouget introduced chitin to a hot potassium hydroxide solution in 1859, he found the primary chitin derivative, chitosan. Gilson established the presence of glucosamine in chitin in 1894, and Hoppe-Seyler gave it the name chitosan the same year[22,23].

BASIC STRUCTURE

The linear structure of chitosan's fundamental structure contains beta-1, 4-O-glycosyl linked to glycosamine traces.
Three distinct functional groups, including amino and amido groups located at position C-2 and hydroxyl groups located at positions C-3 and C-6, make up the active portions of chitosan. As a result, it is simple to derive.[3]

PREPARATION OF CHITOSAN

In general, there are two main ways to make chitosan from chitin with differing degrees of acetylation. They include the homogeneous deacetylation of pre-swollen chitin under vacuum (by lowering pressure) and the heterogeneous deacetylation of solid chitin.The favoured commercial procedure is heterogeneous deacetylation, which involves preferential reactivity in the amorphous parts of the polymer, leaving the difficult-to-treat native crystalline sections in the parent chitin largely untouched. However, homogeneous alteration is carried out by using a moderately concentrated alkali (13% w/w) that acts on pre-swollen chitin to increase the interaction with the alkali and is then allowed to react at 25–40oC for 12–24 hours.[6,7]

APPLICATIONS IN DENTISTRY

A. ORAL SURGERY
B. CONSERVATIVE DENTISTRY
C. PEDIATRIC DENTISTRY
D. ENDODONTICS
E. PERIODONTOLOGY
F. ORAL PATHOLOGY
G. ORTHODONTICS
H. PREVENTIVE DENTISTRY

ORAL SURGERY

Chitosan is used to promote ***wound healing*** as a local hemostatic *or* ***bone regeneration agent***[9].

Regenerative qualities are in fact among its key characteristics. Macrophages are activated, fibroblasts are stimulated to create collagen VI, and cells are stimulated to produce growth factors that aid in regeneration when exposed to Chitosan. For this, the Chitosan encourages the recovery from injuries or traumatic experiences. Additionally, because of its shape, it serves as a scaffold for the creation of bones[8,9]. Chitosan is frequently utilised in oral surgery due to its capacity for regeneration.

In an erupted tooth socket following extraction, chitosan is beneficial in encouraging wound healing and early osteogenesis[8].

Chitosan may also improve the tensile strength of wounds, according to reports[8,10].

Chitosan with a high DDA (degree of deacetylation) encourages the production of osteoblasts and biomineralization. Therefore, ***the healing and osseointegration of dental implants*** in the future can be improved by this combination of laser surface and chitosan[13].

CONSERVATIVE DENTISTRY

In conservative dentistry, the capacity to create a film and gel is particularly helpful for ***preventing caries***[9,11].

By covering the exposed vital pulp with a substance, direct pulp capping preserves the pulp's life and preserves its biological and functional functions. Applying the capping material to the exposed location encourages the growth of reparative dentin. Although many contemporary materials do not meet the clinical requirements, effective pulp capping materials must be biocompatible and have the capacity to encourage the creation of dentin bridges. For clinical applications, Gp-CT material displayed adequate setting time and compressive strength as well as steady pH values. As a potential material for ***direct pulp capping***, Gp-CT (gypsum-based chitosan material) material exhibits promise[14].

Traditional glass ionomer cement (GIC) has many benefits, including the ability to connect to tooth enamel and dentin tissue by itself, the release of fluoride, the prevention of cavities, and the demonstration of antibacterial capabilities by producing a low pH environment. However, numerous drawbacks of GIC's poor mechanical qualities, such as their fragile structure, poor long-term performance under pressures, early humidity sensitivity, insufficient microhardness, and susceptibility to wear[15,16,17] .When combined with chitosan, glass ionomer cement expected to be less susceptible to the oral environment without compromising its mechanical qualities. The results for both the microhardness and surface roughness improved with the addition of Chitosan to GIC. Its usage in the mouth is therefore promising. Due to the stomach acid erosive cycle's relatively low effectiveness, ***Chitosan modified GIC*** seems promising in GERD patients[15].

PEDIATRIC DENTISTRY

Formocresol has earned a reputation for being poisonous, carcinogenic, and mutagenic over time[18,19]. Less people are using formocresol as a pulpotomy medication. It would be preferable to find a substitute for this medication that does not cause the same local and systemic issues.A safe, biocompatible, and efficient treatment option for ***pulpotomy in primary molars*** is chitosan. Chitosan can be utilised as a substitute to formocresol as a pulpotomy agent because of its benefits[19].

ENDODONTICS

Because of its potent antimicrobial properties, it is employed in endodontics. In fact, it affects the root canal bacteria that are the most resilient[9,11]. Chitosan interacts with the bacterial cells' negative charges and destroys intracellular components[9].

Propolis and chitosan-based medications have a variety of applications in the ***endodontic treatment of root canals***, but what is highlighted in particular is their potential efficacy against resistant microorganisms like E. faecalis and C. albicans, as well as being biocompatible to the periapical tissues in comparison to the most commonly used agents. Their therapeutic qualities, such as anti-inflammatory, antifungal, and antiseptic capabilities, make them suited for use in endodontic treatment since they target bacteria that is challenging to eradicate[20].

PERIODONTOLOGY

It functions by preventing periodontal tissue loss and promoting their regeneration. Many scientists concur that Chitosan may be used to replace lost periodontal tissues. Additionally, because of its capacity for regeneration, it creates scaffolds on which osteoblasts can manufacture bone matrix[9,12].

Chitosan brushes may be effective tools for peri-implant inflammation in its early phases and for the removal of plaque that has been professionally applied[21]

When used with toothpaste, mouthwash, and chewing gum, chitosan has ***antibacterial properties*** that help to reduce the number of microorganisms in the oral cavity. Additionally, chitosan has antiplaque efficacy against a number of oral infections, including Aggregatibacter actinomycetemcomitans, Prevotella intermedia, and Porphyromonas gingivalis[23].

According to research, periodontal and gingival fibroblasts' ability to ***inhibit inflammation*** is what causes periodontal disorders to become less painful[23,24].

Formulations containing chitosan stay on the application site for a long period; their capacity for tissue regeneration and hemostasis negate the need for additional materials, such as barrier membranes and bone grafts in regenerative therapies. Additionally, chitosan ***exhibits osteoconductivity*** and induces ***neovascularization***, which speed up the development of new bone[23].

Antibiotics including metronidazole, chlorhexidine, and nystatin are delivered to periodontal tissues using chitosan nanoparticles. When used as an adjuvant to scaling and root planing in chronic periodontal patients, chitosan gel combined with or without 15% metronidazole showed substantial ***improvements in bleeding indices, probing depth, and clinical attachment level***[23,25].

Guided Tissue Regeneration's fundamental approach entails isolating the periodontal defect with a suitable membrane (resorbable or non-resorbable) that acts as a physical barrier to gingival tissue infiltration into the osseous defects, promoting bone regeneration and discouraging the proliferation of fibrous tissue at the same time. The template must have specific biological, physical, chemical, and bioactive properties that promote a favourable host tissue response in a self-contained temporal system conducive to tissue regeneration in order to accomplish this objectively, effectively, and in a therapeutically practical way. A complete GTR membrane therapy system should include a variety of qualities, from strong constructions (smart, bio-integrative, and conducive) to drug delivery applications. The biological behaviour of the inclusive components and appropriate particle size enhance the receptivity to cellular and extracellular matrix stimuli. Chitosan has been identified as a promising substrate material for periodontal tissue regeneration since it complies with the aforementioned qualities[32].

ORAL PATHOLOGY

Because of its intrinsic biocompatibility and antifungal effectiveness, chitosan is a good candidate for use in ***antifungal mouthwash***[26]. The use of low-molecular-weight chitosan solution in the study[26] presents a new and less strenuous therapy technique for denture stomatitis. The findings suggest that the chitosan solution offers a different drug that is clinically equivalent to nystatin for the treatment of stomatitis. The findings could result in the development of an exciting biocompatible and secure antifungal mouthwash.

ORTHODONTICS

Dental hygiene is more difficult for patients with orthodontic attachments, and plaque buildup is simpler around brackets. The study[27] showed that in order to prevent demineralization of enamel during the 60 days of orthodontic treatment, chitosan-containing dentifrice was used, and its use is recommended to ***prevent white-spot lesions***. It was suggested that adding chitosan to dentifrice is an efficient way to ***stop the enamel surrounding brackets from demineralizing***. Dentifrice with chitosan in it may lessen the enamel decalcification seen in people with bad oral hygiene.

PREVENTIVE DENTISTRY

Periodontal disorders are primarily caused by dental plaque. The major objectives of the prevention and treatment of periodontal diseases are the elimination of bacterial biofilms from tooth surfaces and plaque control.The inclusion of various antiseptic ingredients to mouthwash formulations can supplement or take the place of mechanical plaque removal in addition to mechanical plaque control. Clinical investigations shown that several of these antimicrobial medications, when used without cleaning teeth, have inhibitory effects on plaque and gingivitis when compared to placebos or negative controls[28,29,30]**.** The study's[30] findings showed that the mouthwashes we looked at had a variety of inhibitory effects on the test bacteria. The positive results of this study might make it possible to use Chitosan alone or in conjunction with Chlorhexidine as a mouthwash. Chitosan's exact antibacterial mechanism is still a mystery. Additional research will aid in improving Chitosan formulations, whether used alone or in combination with other ***antiplaque medicines***.

Dental caries continues to be a serious public health issue. One of the best ways to stop tooth decay is by using fluoride. In order to distribute fluoride for the early prevention of tooth decay, it is suggested that the fluoride/chitosan nanoparticles created in study [31]may be a promising method. Dental caries affects the enamel chemically as a result of the acidic environment that bacteria cause. Numerous studies have examined the antibacterial capabilities of fluoride and chitosan individually as the best means of preventing tooth decay. In this study, it is demonstrated that the fluoride/chitosan nanoparticles made using ionotropic gelation with TPP have an appropriate size and zeta potential. More fluoride could be absorbed by nanoparticles in vitro, and their releasing profiles were smooth. Fluoride/chitosan nanoparticles may be an unique antibacterial and remineralizing element in toothpaste that helps to ***prevent dental cavities***. The fluoride/chitosan nanoparticles created in this study may enhance the fluoride's effective delivery[31].

Chitosan and chitosan that has been thiolated have been used to create mucoadhesive nanofibre polymers (CS-SH). While CS-SH results in greater mucoadhesion, the medicines' synergistic antibacterial action has demonstrated fast release of the active ingredients. It exhibited good mucoadhesion and decreased oral cavity bacteria without cytotoxicity.According to the findings of a prior study, chitosan-containing polymers may promote oral health by ***lowering the growth of bacteria that cause tooth caries***[3,33].

CONCLUSION

D-glucosamine, derived from the deacetylation of chitin present in the shells of marine crustaceans, is repeatedly converted into a macromolecule known as chitosan (in particular from crabs and prawns).. As a local hemostatic or bone regeneration agent, chitosan is used to facilitate wound healing. High DDA (degree of deacetylation) chitosan promotes biomineralization and osteoblast growth. The ability to make a film and gel is especially useful in conservative dentistry for preventing cavities. Gypsum-based chitosan material, or Gp-CT, shows promise as a viable material for direct pulp capping. Early-stage peri-implant irritation and professionally applied plaque eradication may both benefit from the use of chitosan brushes. Chitosan causes neovascularization and demonstrates osteoconductivity, both of which hasten the growth of new bone. Chitosan gel with or without 15% metronidazole significantly improved bleeding indices, probing depth, and clinical attachment level when administered as an adjuvant to scaling and root planing in chronic periodontal patients. It was suggested that adding chitosan to dentifrice is an effective way to stop the enamel surrounding brackets from demineralizing.

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