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# Applications of Chitosan in Conservative dentistry and endodontics: A Review

# Applications of Chitosan

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***ABSTRACT: Recently the versatile natural biomaterial called chitosan has gained popularity in the field of dentistry. Many studies have been performed and have suggested its various applications Conservative dentistry and Endodontics. Chitosan has numerous properties such as biocompatibility, hydrophilicity, biodegradability, and a broad antibacterial spectrum. Chitosan is used in the prevention of caries and has also shown to increase the regeneration capability of the dentin pulp complex. In pulpotomy it causes haemostasis and also accelerates osteogenesis. It shows antibacterial activity on addition with various restorative material such as glass ionomer cement, calcium hydroxide, and adhesive systems,.The aim of this review is to describe the various available applications of chitosan in conservative dentistry and Endodontics till date.***

***Keywords: Chitosan, Nanoparticles, Antibacterial, Chitin, Biomimetic***.

## 1. INTRODUCTION

The current advances in the scientific and biomedical field have introduced new materials which are being used safely and efficiently. It is observed that the process to obtain biomaterials is difficult and expensive. Nowadays, these biomaterials are effectively used in branches of surgical, orthopedic, reconstructive plastic surgery, aesthetic, and dental material biomaterials. One of the materials used in different fields of dentistry and which has gained popularity is chitosan. Chitosan is a macromolecule which is formed by the repetition of D-glucosamine. It is derived from the deacetylation of chitin, obtained from the shells of marine crustaceans (in particular from crabs and prawns). Chitin is the second most common biopolymer after cellulose, and is indigestible [1].

While studying mushrooms, French Professor Henri Braconnot, first isolated Chitin in 1811. Prof.C. Rougetin 1859 found that on boiling chitin with hot potassium hydroxide solution caused deacetylation of chitin causing formation of an acid soluble substance. This substance was called as Chitosan by Hoppe Seiler [2].

The major properties of chitosan include natural nontoxic, biocompatibile, biodegradable polysacchride, antimicrobial activity, and the ability to form film and gel [3]. Due to all these properties of chitosan, it has shown various applications in the field of Conservative dentistry and Endodontics.

## STRUCTURE OF CHITOSAN

Chitin naturally occurs as microfibrils in shells of arthropods, cell walls of fungi and yeasts. Chitin on thermal maneuvering under strong aqueous alkali gives partially deacetylated chitin called as chitosan. The preferred method for obtaining chitosan is Heterogenous deacetylation. The procedure involves treating chitin with hot solution of NaOH followed by selective reaction in amorphous regions of polymer occurs, leaving the obstinate crystalline intrinsic regions unaltered [4].

Chitosan is composed of copolymers of β-(1,4)- linked glucosamine units (2-amino-2-deoxy-β-Dglucopyranose) and N-acetyl glucosamine units(2- acetamino-2-deoxy-β-D-glucopyranose) with two free hydroxyl groups and one primary amino group for each C6 structure unit. These free amino groups offer chitosan a positive charge which allows its interaction with negatively charged surfaces [5]. Chitosan in contact with anionsforms beads of 1-2mm diameter, large enough to limit drug delivery [6].

### Chitosan nanoparticle

Ohya and co-workers in 1994 developed chitosan nanoparticles by emulsifying and crosslinking, for intravenous delivery of 5-fluorouracil, an anticancer drug [7]. Chitosan nanoparticles are synthesized most commonly by ionotropic gelation and polyelectrolyte complex or by microemulsion, emulsification solvent diffusion, and reverse micellar method [8].

## APPLICATIONS OF CHITOSAN

### Antibacterial effect:

A study demonstrated 1% concentration of chitosan showed bacteriostatic action against S. aureus and P. aeruginosa[9].Another study reported stronger inhibitory effect at low pH and antibacterial activity reduced with increase in the pH[10].

Higher molecular mass increases bactericidal power of chitosan, whereas Lower molar weight chitosan can easily penetrate cell wall of fungi, which affects faster the vital components of cells and physiological activities[11]. Due to phospholipids and carboxylic acids in bacterial cell wall, chitosan presents better bactericidal and bacteriostatic action for Gram-negative bacteria than Gram-positive bacteria[12].

Another study demonstrated application ofchitosan in oral health care as a promising antimicrobial agent and was found that Chitosan caused a reduction in bacterialadhesion and was responsible for bacterial death uponcontact[13]. A study showed Antibacterial effectivity of chitosan is equal to that of chlorhexidine against E. faecalis in biofilm[14].The antibacterial property of chitosan is due to the electrostatic interactions between $NH^{3+}$ of chitosan that binds to bacterial cell surface components and alters the cell permeability and hence results in the leakage of intracellular components and cell death[15].

**Reduction in plaque formation and caries development:**
Chitosan toothpastes, mouthwash solutions and chewing gums have shown antibacterial activity against Streptococci and are effective in reducing bacterial plaque formation and stimulating salivation.The commercially available chitosan-based dentifrice (Chitodent® (B&F)), is a non-fluoridated and shows significant reduction of tissue loss. Studies on association of chitosan with dental materials, suggest that chitosan enhances biocompatibility of materials, favors cell migration and hinders absorption of oral bacteria (S. sanguis, S. mutans, S, mitus, S. salivarius) to the tooth[16]. Chitosan functions as preventive and therapeutic agent for dental caries.Thiolated chitosan based formulations are used in mucoadhesive patches to prevent dental caries [17].

**Smear layer removal**
Chelating property of Chitosan helps to remove inorganic portion of smear layer by forming complexes with metal ions and eliminates dentin calcium ions [18]. In a study describing the effect of Chitosan-EDTA (1:1) on Enterococcus faecalis and removal of smear layer showed it to be a potential root canal irrigant that performs dual role as root canal disinfection and smear layer removal [14].

**Haemostasis and pulpotomy**
Chitosan is one of the most commonly used substances to arrest the bleeding. Celox is an effective hemostatic agent that contains chitosan. The positively charged Celox binds to negatively charged erythrocytes and causes a reaction when in direct contact with blood. This product is a fine granule, which interacts directly with red blood cells and thrombocytes to form a cross-linked clot barrier which is independent of natural factors [19]. In pulpotomy, after removal of the crown pulp chitosan diluted with sterile saline is applied to the pulp chamber. It is left for 15-20 seconds and hemostasis is obtained. Chitosan increases formation of reparative dentin and hard tissue formation. Therefore it is considered to be an appropriate material for pulpotomy.

**Enamel Regeneration:**
Human enamel regenerationwas possible when Organic amelogenin delivery at site of enamel defects with chitosanrestorative formulations was performed. A study explains to rejuvenate the aligned crystal structure using chitosan based hydrogel as a carrier for amelogenin[20].It was reported that chitosan membranes supported the collection of dental pulp cells for the formation of multi-cell spheroids and has been recommended as a promising method for tissue regeneration and therapeutic applications [21].

**Dentin Remineralization:**
Phosphorylated chitosan functions as template-analogues and induces homogenous nucleation. A study reported that stable nanocomplexes of carboxymethylchitosan/amorphous calcium phosphate (CMC/ACP) infiltrated into collagen fibrils due to chelation of calcium ions, causing intrafibrillar mineralization of collagen, thus facilitating remineralization of dentine [22].

**Restorative Materials:**
Chitosan was added to conventional glass ionomer cements (GIC) to evaluate its effect on protein and growth factor release vital pulp therapy. It reported that there was improved flexural strength and increased rate of fluoride release in GIC incorporated with chitosan. For

bioactive dental restorations and regenerative endodontics Chitosan-modified GICs could can used as an option[23].

**Intracanal medication and sealers:**
2% chlorhexidine (CHX) gel and chitosan combination showed highest antimicrobial effect against C. albicansand E. faecalis on comparing with CHX gel or 2% chitosan alone [24]. Chitosan nanoparticles incorporated into zinc-oxide eugenol (ZOE) sealer enhanced antibacterial effects in membrane-restricted assays, suggesting that Chitosan nanoparticles disperse from sealer, piercing into dentinal tubules and anatomical complexities [25]. A study observed that Ca $(OH)_2$ combined with chitosan solutions were more efficacious in inhibiting the growth of E. faecalisas compared with Ca $(OH)_2$ mixed with saline [26]. Another study demonstrated antimicrobial effect of combination of chitosan with Triple Antibiotic Paste and calcium hydroxide against C.albicans and E.faecalis [27].

**Chitosan based adhesives:**
Recently, Bioadhesive polymers and chitosan-based dentine replacement materials have been developed. A study has recommended chitosan to be an element of an "etch and rinse" adhesive system to effectively increase the resistance of dental restorations [28]. Dynamic dentine bonding systems with increased shear bond strength was shown with chitosan hydrogels mixed with Propolis, β carotene and nystatin. The strength was significantly higher than conventional dentine bonding systems irrespective of phosphoric acid etching [29] .
In another study, chitosan when added to adhesives reduced collagen destruction and prevented water permeation in hybrid layers. Thus, suggesting a role for chitosan in eliminatingbacteria from dentin surfaces [30].
In another study, showed the effects of an experimental adhesive system containing chitosan against S. mutans and L. casei. The results were similar to those of the traditional 2-stage adhesive system. It was stated that the addition of chitosan did not affect the antimicrobial effect against these bacteria [31]. Previous studies suggests that the amount of chitosan affects the bonding strength. In contrast, other studies showed no signficant difference was observed in shear bonding strength with adhesives containing 0.12% and 0.25% chitosan with a control group, while the addition of 0.5% and 1% chitosan significantly reduced bonding [32].

## 2. CONCLUSION

This article describes the various applications of Chitosan in the field of Conservative dentistry and Endodontics till date. Chitosan is a biocompatible biopolymer, is currently being used due to its various biological properties. Research is still required to introducenew derivatives of chitosan to expand its applications of chitosan.

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