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REVIEW ARTICLE

ROLE OF MARINE COMPONENTS AND BIOACTIVES IN DENTISTRY – A REVIEW

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ABSTRACT

Aim: To review the literature for evidence based understanding of the application of marine components and bioactives and its significant role in the field of dentistry. This review paper highlights the potential use of bioactive material and molecules from their marine origin to their application in the dental arena.

Background: Marine organisms are exemplary bio-resources that have extensive possibilities in supporting and facilitating development of human tissue substitutes. Marine bioactives are emerging as analysts are finding new applications for them in medicine. Bioactive materials and molecules having significant therapeutic benefits in drug delivery, stem cell therapy, cancer therapy, thrombotic diseases and cosmetic surgery in biomedical. Some of dental therapies like Pulp-capping, Root Canal Therapy (RCT) with bioactive molecules are recent clinical applications. Some natural ceramics, such as calcium hydroxide, spontaneously bond to living bone. This challenges us to explore marine resources more, than just the dietary aspect, as marine medicines have the capacity to sustain humans. Compounds isolated from marine organisms have antimicrobial, antiviral, antitumor and anti-inflammatory potential

Conclusion: Marine organisms have the potential to integrate itself with human tissue and promotes regeneration and healing. Chitosan, bio-adhesives, tissue regeneration gels, calcium hydroxyapatite, gypsum and algal extracts are marine resources exploited in the field of dentistry. It suggests that they possess sophisticated structures, architectures and biomaterial designs that are still difficult to replicate using synthetic processes, so far. This paper helps us better understand the various marine components that can be beneficial to the field of dentistry in particular.

INTRODUCTION

The oceans: The ocean is the Earth's largest ecosystem and is in perpetual darkness as less than 5% of the World Ocean has been explored. It covers 71% of Earth's surface[1] and 90% of the earth's biosphere. The ocean holds 97% of Earth's water,[1] and the total volume is approximately 1.35 billion cubic kilometers (320 million cu mi)[2] with an average depth of nearly 3,700 meters (12,100 ft)[3,4]. As it is the principal component the ocean, it forms part of the carbon cycle, and influences climate and weather patterns. It is the habitat of 230,000 known species, and over two million marine species are estimated to exist[5].

Resources: they sustaining the needs of society from fuel sources to food supplies. A diverse array of marine organisms are used for food, medicine, cosmetics, and a wealth of industrial applications. In the future more electricity will be generated from waves, tidal currents, tidal barrages and offshore wind as the world's demands for energy, minerals and water have become increasingly dependent on non-living marine resources[6].

Exploitation and conservation: Researchers are working to monitoring the impacts that humans have on them through fishing, offshore oil and gas operations, coastal development and municipal and industrial discharges[7]. The once abundant resources are being over exploited that they may face depletion as the are consumed faster than they were created. We need to find ways in which we can improve the stewardship of our seas.

Marine Bioactives and materials in dentistry

Bioactive material and molecules is one of the thrust areas for research and have wide application in dentistry they have capacity to interact with living tissues or system. There are several types of bioactive materials like osteogenic, osteoconductive, osteoinductive. Some ceramics such as hydroxyapatite, calcium hydroxide, silica based glasses[8].

In recent years, there have been compounds from marine sources like coral, sponges and fish. Bioactive materials derived from marine sources include discodermolide, eleutherobin, bryostatins, dolostatins and cephalostatins. Bioactive materials and molecules contain
Antitumor, antiviral, antibacterial and antifungal activity[9]

Biomaterials are native or synthetic polymers that perform as scaffolds for tissue regeneration. Some ceramics, such as Bioglass, sintered hydroxyapatite, calcium hydroxide, mesoporous silica based ceramics and trioxide aggregate, spontaneously bond to living bone and hold wide importance in root canal therapy, tooth repair, pulp therapy and dental surgery. This review paper focuses on the bioactive material and molecules that has been applied in many of the potential research areas in dental Sciences and highlights their marine sources[10].

Marine algal extracts: Marine algae are considered as natural source of promising bioactive compounds owing to the presence of various secondary metabolites [11] characterized by a broad spectrum of biological activites. Anti – viral, anthelmintic, anti-fungal and antibacterial activites of several marine microbes have been identified.

The oral cavity is an abode of oral pathogens, both beneficial and harmful. The prevailing conditions of the mouth favours their multiplication, therefore suppression and control against these microbes is vital for good oral health. Dental caries, periodontal disease and halitosis are conditions prevailing from bad oral hygiene. Dental caries is a highly prevalent disease [12] caused due to cariogenic bacteria and specific dietary habits[13]. The bacteria colonize on the tooth surface and produces acids dissolving tooth structures. Streptococcus mutans, streptococcus sobrinus and lactobacillus casei are popular cavity causing bacteria. Anti – microbial treatments against these organinsms can help control and prevent caries.

Among various algal extracts studied so far, laurencia okamurae Yamada, dictyopteris undulate Holmes and Sargassum micracanthum (Kutzing) Endlicher showed potential anti bacterial activity against all tested oral pathogens. Sargassum micracanthum showed the strongest ani-bacterial activity with 6.0 ± 1.4mm of clear zone against Streptococcus mutans. The colonization of streptococcus sobrinus was effectively inhibited by the extract from Sargassum micracanthum. laurencia okamurae had the strongest susceptibility against streptococcus sobrinus with 9.5±0.7mm of clear zone. S.anginosus, S.aureus and S.epidermis was suppressed by the treatment of laurencia okamurae Yamada, dictyopteris undulate Holmes and Sargassum micracanthum (Kutzing) Endlicher. Sargassum micracanthum (Kutzing) Endlicher showed superior anti-bacterial activities compared to chemical antibacterial agents like streptomycin against oral pathogens. Therefore chemical agents n mothwashes are being switched over to natural biosafe products such as these[14].

Marine algae and seaweeds

Agar

Agar is derived from the polysaccharide agarose, which forms the supporting structure in the cell walls of certain species of algae which belong to Rhodophyta (red algae) phylum[15,16]. Agar is actually the resulting mixture of two components: the linear polysaccharide agarose, and a heterogeneous mixture of smaller molecules called agaropectin[17]. Agar is the dried gelatinous substance, obtained from G.amansii Lamouroux, G.cartilagineum Gall, G.pristoides Turn Kiitz, etc., belonging to the family Gelidiaceae, Rhodophyceae (red Algae). Algae are removed, dried, beaten and shaken to remove shell and sand. The algae are bleached by sun light, then boiled with acidulated water. Mucilaginous mass is and finally, agar is dried at 35°C[18].

An agar plate or Petri dish is used to provide a growth medium using a mix of agar and other nutrients in which microorganisms, including bacteria and fungi, can be cultured and observed under the microscope. Thus it is indispensible from the aspect of dental research. . For many years, agar impression material has been a staple of most dental practices. Agar is a reversible hydrocolloid because it can pass repeatedly between highly viscous gel and low viscosity sol simply through heating and cooling[19]. Agar was first introduced into dentistry for recording crown impressions in 1937 by Sears[20] and was the first elastic impression material available. It is not commonly used practice today.

Alginate

Alginic acid, also called algin or alginate, is an anionic polysaccharide distributed widely in the cell walls of brown algae, where through binding with water it forms a viscous gum. Alginates are refined from brown seaweeds of the phylum *Phaeophyceae* and is harvested as sodium alginate or potassium alginate(potassium salt of alginic acid)[21] Cold mould seal which contains active components sodium alginate reacts with calcium alginate in the cast and forms a separating medium[20]. Sodium alginate is one of the most frequently used dental materials; and alginate impression is a simple, cost-effective, and indispensable part of dental practice[22]. However, alginate once converted to the gel form cannot be converted back into the sol, and is therefore said to be irreversible hydrocolloid material[23].

Alginate and agar produce impressions with reasonable surface detail. They are both relatively hydrophilic and are not displaced from wet surfaces as easily as the elastomers[24].

Fucoidan

Found mainly in marine brown algae is the sulphated polysaccharide fucoidan capable of controlling the acute and chronic inflammatory response. It posses interesting properties that may lead to prevention of the disease of cancer[25]. It suppress the expression and secretion of various angiogenesis factors thereby produce inhibitory effect on angiogenesis of tumor cells[26].A blended hydrogel consisting of chitosan, alginate and fucoidan has found successful application in healing-impaired wound dressing[27].

Calcium phosphate and Hydroxyapatite

Recently, hydroxyapatite [Ca10(PO4)6(OH)2] has been introduced as a bone graft material in a dentisrty. Aautografts, allografts and xenografts do not provide perfect bone healing due to mechanical instability and incompatibility. Currently, calcium phosphate bioceramics such as tetracalcium phosphate, amorphous calcium phosphate, tricalcium phosphate and Hydroxyapatite are identified. Fish bone now has biomedical applications due to the presence of Hydroxyapatite as the major inorganic constituent which is an excellent biocompatible inorganic substance[28,29,30]. In fact, it is thermodynamically stable at physiological pH and actively takes part in bone bonding. This property has been exploited for rapid bone repair after major trauma or surgery. Hydroxyapatite is derived from natural materials such as coral and fish bone[31]. Attempts have been taken to isolate fish bone derived hydroxyapatite and use them as an alternate for synthetic hydroxyapatite[32,33]. Very high heat treatment (_1300 _C) is used for isolation, as it gives a higher strength to hydroxyapatite structure[34].

Crustaceans

Shrimp chitin antibacterial activity has also been reported[35]. coralline calcite or aragonite has been successfully applied for replacement of fractured bone due to their ability of forming strong chemical bond with in vivo soft tissue and bone[36.] Its porous crystalline structure permits the blood supply for the newly formed bones by allowing in growth of blood vessels ultimately infiltrating the implant[37].

Chitosan

Chitosan is a natural polymer of chitin (crustacean exoskeleton) and plays a major role in bone tissue engineering as potential material for artificial bone[38]. Chitosan composite materials and their applications in the field of bone tissue engineering due to its minimal foreign body reactions, an intrinsic antibacterial nature, biocompatibility, biodegradability, and the ability to be molded into various geometries and forms such as porous structures, suitable for cell ingrowth and osteoconduction[39]. Grafted chitosan natural polymer with carbon nanotubes increases the mechanical strength of these composites[40,41]. The combination of biocompatible polymers and bioresorbable ceramic materials can mimic the natural function of bone. CTS with HAp composites have good osteoconductive, osteoinductive and osteogenic properties.

Partially deacetylated chitin as well as chitin with a carboxymethyl group have also been effective to demote tumor progression[42]. It posses immunostimulating effects via stimulation of cytolytic T-lymphocytes. This activates peritoneal macrophages and stimulates non-specific host resistance. However, higher molecular weight oligomers also have exhibited antitumor activity[43]. Involvement of chitin and chitosan in wound-healing involves higher production of macrophages, that release cytokines necessary for the healing process[44]. Their ability to stimulate fibroblast production by affecting the fibroblast growth factor promotes healing. Subsequent collagen production further facilitates the formation of connective tissues[45]. Chitosan and chitosan oligomers act as antioxidants by scavenging oxygen radicals[46]. All these aspects are beneficial to the field o dentistry.

Marine Sponges

Sponges are the most primitive of all the multi cellular organisms that have been existing 700-800 million years Marine sponges produce an enormous array of antitumor, antiviral, anti-inflammatory, that have the potential for therapeutic use. Scientists in the field of natural products chemistry and research suggest that sponges have the potential to provide future drugs against important diseases, such as a range of viral diseases, malaria, inflammations, immunosuppressive diseases and various malignant neoplasms[47-50]. A number of metabolites derived from marine sponges, such as indole derivatives, aromatic alkaloids, aromatic polyketides, and phenolic compounds have exhibited strong antioxidant potential compared to vitamin E and ascorbic acid. The most important antitumour compound from marine species was Trabectedin (Yondelis/ecteinascidin-743/ET-743) from a tropical sea-squirt. It was approved by the European Union in 2007 (European Agency for the Evaluation of Medicinal Products) for the treatment of soft-tissue sarcoma[49,51].The skeletal formation of *demospongiae*, *hexactinellida*, *calcarea* etc. can be attributed as natural bio composite material based on rigid glass or calcium carbonate consequently increasing the possibility of developing a novel bone replacement biomaterial[52,53].

Biosilica

Bio derived silica, commonly termed as biosilica, is derived from sponges, diatoms, choanoflagellates and radiolarians. It has been identified as a bio composite with high flexibility and toughness which could be credited to their layer based structural organization and hydrated nature[54]. It has a wide range of applications involving bone tissue replacement, soft tissue augmentation, maxillofacial reconstruction, etc[55]. Biosilica induces the expression of the important mediator BMP 2 which is responsible for inducing the differentiation of bone forming progenitor cells and also inhibits the function of osteoclasts. Recently silicon substituted hydroxyapatites are being developed which increases the bioactivity and mechanical properties of bone substituted material. The increased bioactivity leads to excellent osteo integration by promoting the reaction between bone and implant owing to increase in solubility of the material[56].

Gypsum

Gypsum is a common mineral, with thick and extensive evaporite beds in association with sedimentary rocks. Deposits are known to occur in strata from as far back as the Archaean eon[57].Gypsum is deposited from lake and sea water. Gypsum is a white powdery mineral with the chemical name calcium sulphate dihydrate ($CaSQ_4 \cdot 2H_2O$). Their main uses in dentistry are for cast preparation, models and die, impression material, investment material, mounting of casts and as a mold material for processing of complete dentures[58].

CONCLUSION

Organisms and components from the marine environment can be implemented in regenerative in dentistry to help address common clinical problems, particularly those regarding loss of bone. These structural products range from small microscopic skeletons to large macroscopic structures. The different applications of marine products have been summarized. Indeed, in addition to their use in dentistry, numerous materials derived from marine sources have been applied in medicine. The astounding range of marine life will lead to significant discoveries in marine materials and biostructures.

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