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Evaluation of the antimicrobial activity of heat-cure denture base resin materials incorporated with silver nanoparticles

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ABSTRACT

Background: Poly (Methyl methacrylic acid) based materials are the most widely used for the fabrication of removable complete and partial dentures. Certain microorganisms adhere to the tissue surface of a denture base, especially on palatal region, often leading to Denture stomatitis. Numerous attempts were made to treat the denture stomatitis with various antifungal agents showing variable success rates. This may be attributed to the loss of the drug rapidly into the saliva, inhomogeneous distribution of the drug and the development of resistance to antifungal therapy.

Aim: This study was done to evaluate the effect of incorporating various concentrations of silver nanoparticles on the antimicrobial activity of heat-cure denture base resin materials.

Materials and methods: Silver nanoparticles were incorporated at various concentrations (0.5, 1.0, 2.0 and 5.0 wt%) into three heat-cure denture base materials. A total of 300 disc-shaped specimens (10 × 2 mm) of heat-cure acrylic resin were made using compression molding technique which comprises 100 specimens with each denture base material. Fifty specimens from each denture base materials were allocated to each microorganism used in the study which comprises into five groups with ten specimens (n=10) for each concentration such as control, 0.5wt%, 1.0wt%, 2.0wt% and 5.0wt% concentrations of silver nanoparticles. Antimicrobial activity of control and modified specimens were evaluated using direct contact method against *C albicans,* and *S Mutans* by counting the number of colony-forming units. The data were subjected to One way ANOVA and Tukey HSD tests for statistical analyses.

Results: Significant($P<0.05$) differences were observed in the antimicrobial activity against *C albicans* and *S Mutans* between the control and modified groups of heat-cure denture base resin materials.

Conclusion: Silver nanoparticles are the favourable materials to incorporate into denture base materials as they exhibit superior antimicrobial activity.

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1. Introduction

Dentistry witnessed the evolution of denture base materials from bone, wood and ivory to cellulose plastics and Poly (methyl methacrylate) in time. Due to favourable working characteristics, accurate fit, stability in the oral environment, superior aesthetics, and ease of processing with inexpensive equipment, PMMA has been the material of choice since 1939. Despite its advantages, PMMA exhibits frequent fracture of dentures because of fatigue and chemical degradation of the base material, low thermal conductivity [1-4], and ease of microbial adherence to the intaglio surface [6,7]. Reinforcing the denture base materials with various metallic fillers, fibres [3] and grafting PMMA with styrene rubber [3] may have compensated the strength issues but the problem of microbial adhesion remains critical for PMMA often leading to Denture stomatitis (DS) [6-8].

Denture stomatitis is the most common consequence of prolonged denture wearing, improper cleaning practices, ill-fitting dentures and biofilm formation on the prosthetic surface. Though the condition has not been considered severe, it may result in chronic inflammation and infection in the elderly or immune-compromised patients [6-8]. The treatments for this Candidal infection include removal of the source of irritation and applying antifungal agents orally in the form of drops, lozenges, cream, pastille, lacquer, gel or mouthwashes [6-8]. However, such attempts have mostly been unsuccessful due to the loss of the drug rapidly into the saliva, inhomogeneous distribution of the drug and the development of resistance to antifungal therapy. Therefore, alternative method to hinder the candidal adherence like addition of antimicrobial additives to conventional PMMA formulation has been attempted. Limited research is available exploring the possibility of formulating a suitable denture base material with potent antifungal activity. In this regard, nanoparticles of silver, titanium dioxide, and silver vanadate are essential precursors for the development of newer functional devices as they improve physical properties by increasing surface area yet efficiently preventing the growth of several microorganisms including Candida, Salmonella, Staphylococcus, and Escherichia coli. Because of their proven antimicrobial activity, experimental incorporation of these nanoparticles into various materials for biomedical applications has been studied[9-12]. The purpose of this study is to evaluate the antimicrobial effect of denture base resin modified with the addition of silver nanoparticles.

2. Materials and methods

2.1 Materials

Silver nanoparticles (nanolabs, India) with an average particle size of 80-100 nm were incorporated at various concentrations (0.5, 1.0, 2.0 and 5.0 wt%) in to three heat-cure denture base materials such as Trevlon (Dentsply), Lucitone (Dentsply) and TriplexHot (Ivoclaur Vivadent) were used in the study. A total of 300 specimens (10 × 2 mm) of heat-cure acrylic resin were made which comprises 100 specimens with each denture base material. The specimens from each denture base materials were divided into 50 specimens for each microorganism used in the study. The 50 specimens were again divided in to five groups with 10 specimens (n=10) for each concentration such as control, 0.5wt%, 1.0wt%, 2.0wt% and 5.0wt% concentrations of silver nanoparticles.

2.2 Methods

2.2.1 Making of acrylic specimens

Acrylic specimens were fabricated by investing the rectangular metal discs in a dental flask. The lower half of the dental flask was filled with a freshly mixed dental stone. Subsequently, the metal disc was carefully seated at the centre of the mix before it’s initial set. On reaching its initial set, the stone was coated with a cold mold seal to prevent the stone mix that would be poured into the upper half of the flask from adhering to that in the lower half. After complete setting of the stone mix, the middle member of the dental flask was placed and filled with a stone mix. The lid was placed and secured in a dental clamp and allowed the stone mix to set. Metal strips were carefully removed after the investment medium was set. A thin layer of separating medium was applied in the mould space and allowed to dry. The mould was then ready to be used for the preparation of acrylic specimen.

The acrylic specimens were made by mixing PMMA resin powder with the MMA liquid in the ratio of 3:1 respectively. Control group test specimens were made with conventional heat polymerized PMMA resin polymer and monomer mixed and allowed to reach dough consistency. For the reinforced specimens, the silver nanoparticles with the concentration of 0.5%, 1%, 2% or 5% by weight were mixed with monomer liquid prior to mixing it with the acrylic powder. Dough thus formed was kneaded and then packed into the mould, flask is closed and bench cured for 30 minutes under pressure in a hydraulic press apparatus. Then the flask was tightly secured in a clamp and transferred into a thermostatically controlled water bath/ acrylizer. The packed acrylic resins were cured according to the manufacturer's instructions. After the curing process is completed, the specimens were carefully removed from the investment mold and the excess material was trimmed followed by finishing and polishing with pumice slurry and rouge respectively.

2.2.2 Evaluation of antimicrobial activity

Antimicrobial activity of the unmodified and modified denture base materials was evaluated against *Streptococcus mutans* (*S. mutans*) and *Candida albicans* (*C. albicans*). American type culture collection (ATCC) approved *S. mutans* strain 25175 and American type culture collection (ATCC) approved *C. albicans* strain 90028 in brain-heart infusion (BHI) broth with concentration of 0.5McFarland were prepared (1 mL of this solution contains approximately 1×10^8 bacteria). Subsequently, the solution was diluted to achieve a concentration of 1×10^5 bacteria in 1 mL. The acrylic resin discs were sterilized in an autoclave. A sampler was used to place 0.01 mL of the bacterial suspension on the surface of the disc samples. Then the samples containing bacterial suspension were incubated in an incubator for 2 hours at 37^0 C to vaporize the water. The samples were placed in test tubes containing sterile 0.5 mL BHI broth and incubated in an incubator at 37^0 C for overnight (around 12 hours). After 12 hours of incubation, a sterile sampler was used to retrieve 0.01 mL from each liquid culture media to uniformly spread on a blood agar plate. The blood agar plates were incubated for 48 hours at 37^0 C and then the numbers of bacterial colonies (Colony Forming Unit, CFU) were visually counted.

2.2.3 Scanning electron microscopy

Acrylic specimens were vacuum dried in a desiccator containing silica gel until a constant weight is obtained. The dried specimens were gold sputtered and were subjected to scanning electron microscopy at 10 kV.

The data was subjected to One way ANOVA and TukeyHSD tests for statistical analyses using SPSS for windows, Version 21.0., SPSS Inc.

3. Results

Figures 1 to 6 show the antimicrobial activity of denture base materials incorporated with AgNPs. The mean colony forming units along with standard deviation observed during the study are presented in Table 1. Control groups of denture base materials showed no antifungal activity against *C. albicans* and *S. Mutans*. However, denture base materials modified with various concentrations of silver nanoparticles showed significant decrease in colony forming units and exhibited superior antimicrobial activity against *C. albicans* (Figures 1-3) and *S. Mutans* (Figures 4-6). Relatively similar anti-candidial activity has been observed among the modified groups at various concentrations of AgNPs. Significant differences (p=0.000) were observed between unmodified and modified denture base resins against *C. Albicans* and *S. Mutans*. However, the anti-candidal activity observed with denture base materials at different concentrations of AgNPs was relatively similar hence considered insignificant. An increase in colony forming units was observed as the concentration of AgNPs increased among the modified against *S. Mutans*. However, modified TriplexHot denture base material showed more antimicrobial activity against *S. Mutans* than the other two denture base materials even at higher concentrations. Denture base materials modified with 5.0wt% of AgNPs showed significant differences (p=0.015) among them. Scanning electron microscopic analysis showed agglomeration of nanoparticles as their concentration increases (Figure 7).

4. Discussion

Nanotechnology, a field of science concerning the nano-sized matter, has brought alteration of properties and characteristics of materials at atomic and molecular levels possible [13,14]. This field has revolutionised various scientific specialities, including dentistry [13-15]. Incorporating antimicrobial efficacy to dental biomaterials using nanoparticles seemed a feasible solution to prevent denture stomatitis by barricading microbial accumulation on PMMA. One such element which had potent bactericidal efficiency in spite of bei-

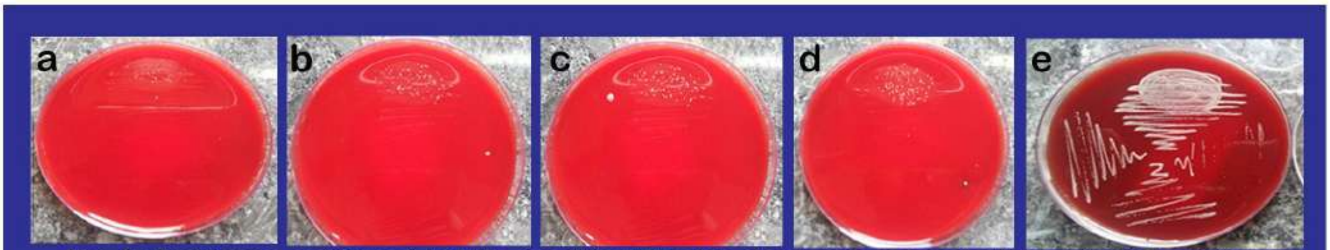

Fig.1: Antifungal activity of AgNPs modified Trevlon denture base material against C. albicans

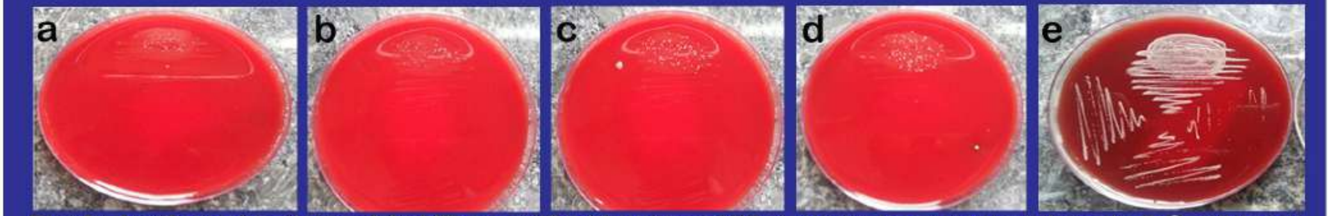

Fig.2: Antifungal activity of AgNPs modified Lucitone199 denture base material against C. albicans

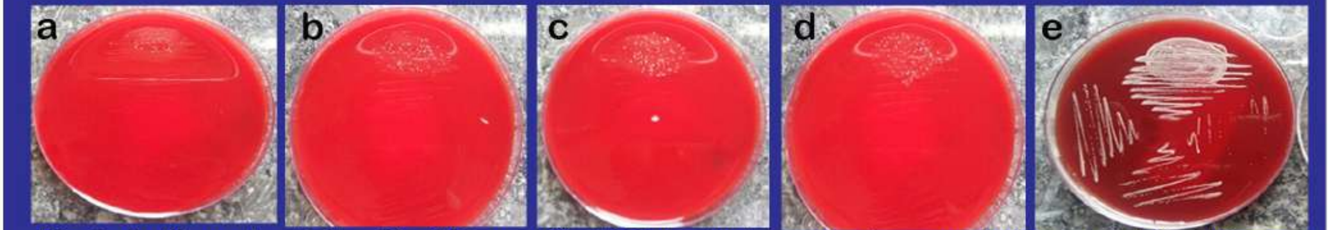

Fig.3: Antifungal activity of AgNPs modified Triplex Hot denture base material against C. albicans

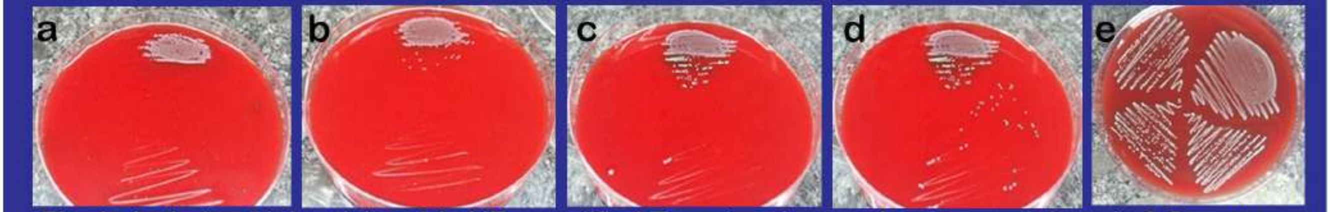

Fig.4: Antimicrobial activity of AgNPs modified Trevalon denture base material against S. mutans

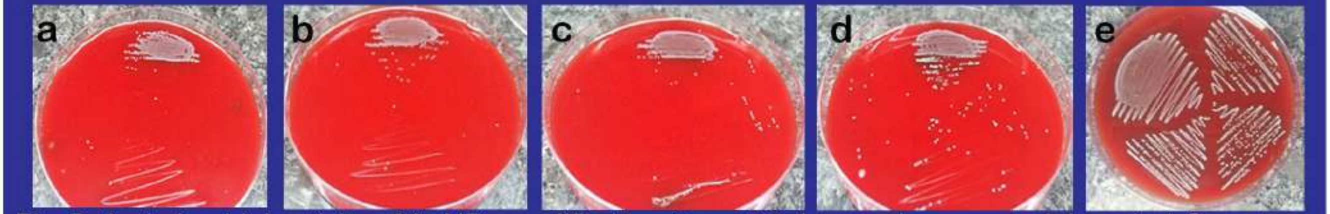

Fig.5: Antimicrobial activity of AgNPs modified Lucitone199 denture base material against S. mutans

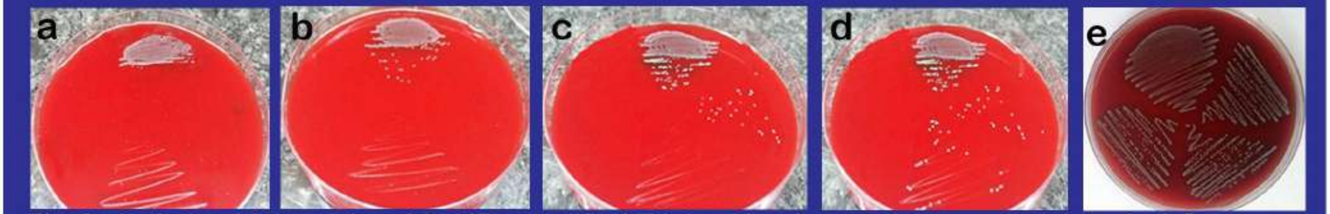

Fig.6: Antimicrobial activity of AgNPs modified Triplex Hot denture base material against S. mutans

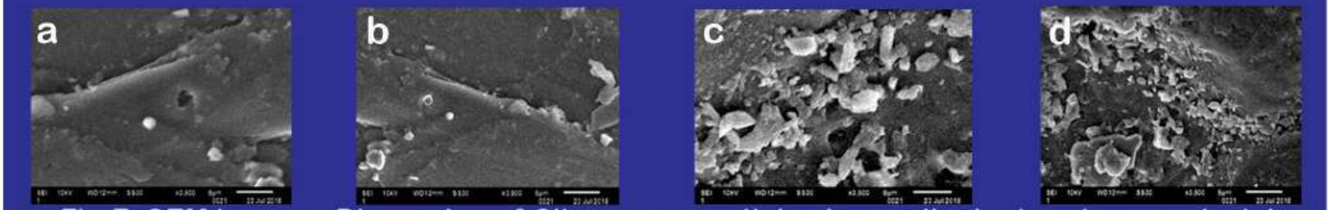

Fig.7: SEM images: Dispersion of Silver nanoparticles in acrylic denture base material

* a. 0.5wt% AgNPs b. 1wt% AgNPs c. 2wt% AgNPs d. 5wt% AgNPs e. Control

ing non-toxic to human cells was silver [16-18]. The present study thus attempted to evaluate the antimicrobial nature of denture base resins incorporating silver nanoparticles which had proven antibacterial effect in the field of medicine. The micro-organisms targeted were Streptococcus mutans and Candida Albicans due to their significant role in DS and dental caries.

Many researchers have proposed the Agar disc diffusion technique to evaluate the antibacterial properties of cured acrylic resins [15,19]. However, inhibitory halo has not been formed around the cured PMMA/NPs composite resin discs; indicating no release of antibacterial agents into the medium, thereby negating the use of this method[19-22]. Therefore, antimicrobial activity of denture base materials was evaluated using direct contact technique and BHI broth culture media in the present study. As this liquid medium contains both live and dead bacteria, 0.001 ml from each bacterial suspension tube was cultured on blood agar medium to trace and count the live and active colonies.

The results of the present study showed that the number of colonies of viable bacteria in the control group was significantly higher than that in the nanoparticle modified groups, demonstrating the antimicrobial activity of acrylic resins containing AgNPs, against *S. mutans*, and *C. albicans*. Studies show antimicrobial activity mainly depends on the efficacy, particle size and distribution of nanoparticles in the resin matrix along with the composition of denture base acrylic resins [23,24]. Results also suggest incorporation of silver nanoparticles suppress the growth of *S. mutans* in a dose-dependent manner, unlike that seen with *C. albicans*.

The results of this study are similar to the findings of Acosta-Torres *et al.* (2012) [25] and Issa *et al.* (2015) who reported acrylic resins and soft relining materials incorporated with AgNPs exhibited higher antifungal property. These studies also suggested the disk diffusion method to be unsuitable for resin materials as they could not release any antimicrobial agents [26]. Wady AF *et al.* also found no inhibitory effect on *C. albicans* adherence and biofilm formation with incorporation of AgNPs into denture base resin [27]. However, Kamikawa *et al. (*2014) [28] coated AgNPs on acrylic denture base resin discs and reported its inhibitory effect on adhesion of Candida to the denture surface thereby preventing Oral Candidosis. Therefore, AgNPs effectively inhibited fungal adherence to acrylic resins but did not exhibit potent antifungal capability [27].

Concentration of AgNPs	*C. albicans*			*S. mutans*		
	Trevlon	**Lucitone 199**	**TriplexHot**	**Trevlon**	**Lucitone 199**	**TriplexHot**
Control	4.0000 ± 0.000	4.0000±0.000	4.0000±0.000	4.0000± 0.000	4.0000±0.000	4.0000±0.000
0.5wt%	0.5200 ± 0.252	0.5200 ± 0.252	0.4600 ± 0.189	0.4600 ± 0.189	0.4600 ± 0.189	0.4600 ± 0.189
1.0wt%	0.5200 ± 0.252	0.5200 ± 0.252	0.5800 ± 0.289	0.8800 ± 0.252	0.9400 ± 0.189	0.8800 ± 0.252
2.0wt%	0.5800 ± 0.289	0.5200 ± 0.252	0.5200 ± 0.252	2.0000 ± 0.000	1.8000 ± 0.421	1.6000 ± 0.516
5.0wt%	0.5800 ± 0.289	0.5200 ± 0.252	0.5800 ± 0.289	2.9000 ± 0.316	2.7000 ± 0.483	2.3000 ± 0.483

Table 1. Antimicrobial activity, Colony forming units, of denture base materials incorporated with silver nanoparticles (mean x 10^2 ± SD).

The antifungal activity of NPs can be due to the increased ROS and radical hydroxyl production on exposure to *C. albicans*. As a result, mitochondrial dysfunction and mutation in CDC48 or expression of mammalian Bax occur leading to apoptosis[29]. So, generation of oxygen radicals is an essential event in the ancestral apoptotic pathway of yeast [30].

S. mutans is a known etiological factor; playing a vital role in dental plaque formation and thereby in dental caries and periodontal problems [31]. In the present study, incorporation of 0.5wt% AgNPs exhibited superior antimicrobial activity against *S. mutans* which decreased slightly on increasing the nanoparticle concentration to more than 0.5wt%. A possible reason for this observation could be due to the addition of NPs in the powder form which might result in particle-particle aggregation at higher concentrations. Such an aggregate may reduce the active surface area available for the antimicrobial action [32,33]. In this study, particle aggregation was evident in the scanning electron microscopic images of the NPs modified acrylic specimens (Figure 7). Similarly, Azarsina *et al.* (2013) [34] also reported an insignificant decrease in the antibacterial activity against *S. mutans* as the concentration of AgNPs increased in the resin composites from 0.5wt% to a maximum of 1.0wt%. In contrast to this, previous investigations using a colloidal solution of AgNPs may have led to their uniform distribution reducing the chances of aggregation and therefore, the superior antimicrobial activity even at higher concentrations [35-39].

Conclusion

Within the limitations of the present in vitro study, it can be concluded that the incorporation of silver nanoparticles reported significant antimicrobial activity to the denture base materials tested. Silver nanoparticles showed superior resistance to the *C albicans* at all concentrations used in the study. However, a decrease in antimicrobial activity was observed against *S mutans* as the concentration of silver nanoparticles increased.

Conflicts of interest: *None*

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References

1. Anusavice KJ. Denture Base Materials (in) Science of Dental Materials. 11th edition, Saunders, India, 2010: 721-758.
2. Alla RK. Denture Base Materials (in) Dental Materials Science. 1st edition, Jaypee Medical Publishers Pvt. Ltd., India, 2013; 248-284.
3. Alla RK, Suresh Sajjan MC, Ramaraju AV, Ginjupalli K, Upadhya NP. Influence of fiber reinforcement on the properties of denture base resins. J Biomater Nanobiotech. 2013; 4(1):91-97.
4. Alla RK, Raghavendra Swamy KN, Ritu Vyas, Konakanchi A. Conventional and Contemporary polymers for the fabrication of denture prosthesis: part I – Overview, composition and properties. Int J App Dent Sci. 2015;1(4):82-89.
5. Rama Krishna Alla, K. N. Raghavendra Swamy, Ritu Vyas, Anusha Konakanchi, Vineeth Guduri, Praveen Gadde. Influence of Silver Nanoparticles Incorporation on Flexural Strength of Heat-cure Acrylic Denture Base Resin Materials. Annual Research & Review in Biology. 2017;17(4):1-8.
6. Najla S. Dar-Odeh, Mohammad Al-Beyari, Osama A. Abu-Hammad, The role of antifungal drugs in the management of denture-associated stomatitis, The International Arabic Journal of Antimicrobial Agents 2(1); 2012:1-5.
7. KN Raghavendra Swamy, Rama Krishna Alla, Shammas Mohammed, Anusha Konakanchi. The Role of Antifungal Agents in Treating Denture Stomatitis. Research Journal of Pharmacy and Technology. 2018;11(4):1365-1369.
8. Pachava KR, Shenoy KK, Nadendla LK, Reddy MR, Denture Stomatitis – A Review, Ind J Dent Adv 5 (1);2013: 1107-1112.
9. Nagy A, Harrison A, Sabbani S, Munson RS, Dutta PK, Waldman WJ. Silver nanoparticles embedded in zeolite membranes: release of silver ions and mechanism of antibacterial action. Int J Nanomedicine 2011;6:1833–52.
10. Stoimenov P, Klinger R, Marchin G, Klabunde K. Metal Oxide Nanoparticles as Bactericidal Agents. Langmuir 2002;18:6679–86.
11. Nomiya K, Yoshizawa A, Tsukagoshi K, Kasuga NC, Hirakawa S, Watanabe J. Synthesis and structural characterization of silver(I), aluminium (III) and cobalt (II) complexes with 4-isopropyltropolone (hinokitiol) showing noteworthy biological activities. Action of silver(I)-oxygen bonding complexes on the antimicrobial activities. J Inorg Biochem.

2004;98:46–60.

12. Marambio-Jones C, Hoek EMV. A review of the antibacterial effects of silver nanomaterials and potential implications for human health and the environment. J Nanoparticle Res. 2010;12:1531–51.
13. Sahoo SK, Parveen S, Panda JJ. The present and future of nanotechnology in human health care. Nanomedicine Nanotechnol Biol Med. 2007;3:20–31.
14. Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. Biotechnol Adv 2009;27:76–83.
15. Kumar R, Münstedt H. Silver ion release from antimicrobial polyamide/silver composites. Biomaterials 2005;26:2081–8.
16. Svanberg M, Mjör IA, Orstavik D. Mutans streptococci in plaque from margins of amalgam, composite, and glass-ionomer restorations. J Dent Res 1990;69:861–4.
17. Bürgers R, Eidt A, Frankenberger R, Rosentritt M, Schweikl H, Handel G, et al. The anti-adherence activity and bactericidal effect of microparticulate silver additives in composite resin materials. Arch Oral Biol 2009;54:595–601.
18. Li LH, Deng JC, Deng HR, Liu ZL, Xin L. Synthesis and characterization of chitosan/ZnO nanoparticle composite membranes. Carbohydr Res 2010;345:994–8.
19. Imazato S. Antibacterial properties of resin composites and dentin bonding systems. Dent Mater 2003;19:449–57.
20. Bundy KJ, Butler MF, Hochman RF. An investigation of the bacteriostatic properties of pure metals. J Biomed Mater Res 1980;14:653–63.
21. Azarsina M, Kasraei S, Yousefi-Mashouf R, Dehghani N, Shirinzad M. The Antibacterial Properties of Composite Resin Containing Nanosilver against Streptococcus mutans and Lactobacillus. Patil SG, editor. J Contemp Dent Pract 2013; 14: 1014–8.
22. Kasraei S, Sami L, Hendi S, AliKhani M-Y, Rezaei-Soufi L, Khamverdi Z. Antibacterial properties of composite resins incorporating silver and zinc oxide nanoparticles on Streptococcus mutans and Lactobacillus. Restor Dent Endod 2014;39:109–14.
23. Yoshida K, Tanagawa M, Matsumoto S, Yamada T, Atsuta M. Antibacterial activity of resin composites with silver-containing materials. Eur J Oral Sci 1999;107:290–6.
24. Spencer CG, Campbell PM, Buschang PH, Cai J, Honeyman AL. Antimicrobial effects of zinc oxide in an orthodontic bonding agent. Angle Orthod 2009;79:317–22.
25. Acosta-Torres LS, Mendieta I, Nuñez-Anita RE, Cajero-Juárez M, Castaño VM. Cytocompatible antifungal acrylic resin containing silver nanoparticles for dentures. Int J Nanomedicine 2012;7:4777–86.
26. Issa MI, Abdul-Fattah N. Evaluating the effect of silver nanoparticles incorporation on antifungal activity and some properties of soft denture lining material. J Baghdad Coll Dent 2015;27:17–23.
27. Wady AF, Machado AL, Zucolotto V, Zamperini CA, Berni E, Vergani CE. Evaluation of Candida albicans adhesion and biofilm formation on a denture base acrylic resin containing silver nanoparticles: Antifungal activity of silver nanoparticles. J Appl Microbiol 2012;112:1163–72.
28. Kamikawa Y, Hirabayashi D, Nagayama T, Fujisaki J, Hamada T, Sakamoto R, et al. In Vitro Antifungal Activity against Oral Candida Species Using a Denture Base Coated with Silver Nanoparticles. J Nanomater 2014;2014:1–6.
29. Hwang I, Lee J, Hwang JH, Kim K-J, Lee DG. Silver nanoparticles induce apoptotic cell death in Candida albicans through the increase of hydroxyl radicals. FEBS J 2012;279:1327–38.
30. Madeo F, Fröhlich E, Ligr M, Grey M, Sigrist SJ, Wolf DH, et al. Oxygen stress: a regulator of apoptosis in yeast. J Cell Biol 1999;145:757–67.
31. Michalek SM, Hirasawa M, Kiyono H, Ochiai K, McGhee JR. Oral ecology and virulence of Lactobacillus casei and Streptococcus mutans in gnotobiotic rats. Infect Immun 1981;33:690–6.
32. Lara HH, Garza-Treviño EN, Ixtepan-Turrent L, Singh DK. Silver nanoparticles are broad-spectrum bactericidal and virucidal compounds. J Nanobiotechnology 2011;9:30.
33. Ginjupalli K, Shaw T, Tellapragada C, Alla R, Gupta L, Perampalli NU. Does the size matter? Evaluation of effect of incorporation of silver nanoparticles of varying particle size on the antimicrobial activity and properties of irreversible hydrocolloid impression material. Dent Mater 2018;34:e158–65.
34. Azarsina M, Kasraei S, Yousefi-Mashouf R, Dehghani N, Shirinzad M. The Antibacterial Properties of Composite Resin Containing Nanosilver against Streptococcus mutans and Lactobacillus. J Contemp Dent Pract 2013; 14: 1014–8.
35. Panacek A, Kvítek L, Prucek R, Kolar M, Vecerova R, Pizúrova N, et al. Silver Colloid Nanoparticles:

Synthesis, Characterization, and Their Antibacterial Activity. J Phys Chem B 2006;110:16248–53.

36. Lkhagvajav N, Ya I. Antimicrobial Activity of Colloidal Silver Nanoparticles Prepared By Sol-Gel MethoD. Dig J Nanomater Biostructures 2011;6: 149–54.
37. Agnihotri S, Mukherji S, Mukherji S. Size-controlled silver nanoparticles synthesized over the range 5–100 nm using the same protocol and their antibacterial efficacy. RSC Adv 2013;4:3974–83.
38. Ahrari F, Eslami N, Rajabi O, Ghazvini K, Barati S. The antimicrobial sensitivity of Streptococcus mutans and Streptococcus sangius to colloidal solutions of different nanoparticles applied as mouthwashes. Dent Res J 2015;12:44–9.
39. Guzman M, Dille J, Godet S. Synthesis and antibacterial activity of silver nanoparticles against gram-positive and gram-negative bacteria. Nanomedicine Nanotechnol Biol Med 2012;8:37–45.

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Recent Advances in Dental Composites: An Overview

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ABSTRACT

Composite resins are widely used aesthetic materials in restorative dentistry. These materials were introduced to overcome the inherent shortcomings of amalgam restorative materials. Dental amalgams are unesthetic and toxic. Earlier composites lack in mechanical properties to withstand the masticatory forces. Various filler particles have been added to composite resins to improve their physical and mechanical properties. Filled composite resins exhibit high compressive strength, abrasion resistance, ease of application and high translucency. Depending on the filler size and shapes, various composites have been developed until now. This article is a review of numerous types of composites that are technologically advanced to modify their properties.

1. Introduction

The acrylic resin was introduced to the dental profession in the mid-1950's, and it replaced the silicate cement soon from the dentistry as a direct aesthetic restorative material. Since their introduction, acrylic-based materials have continued to play a significant role in restorative and prosthetic dentistry [1-3]. The advantages of these acrylic resins include tooth-like appearance, ease of manipulation insolubility in oral fluids, and low cost. However, these materials could not accomplish the requirements of restorative materials as they undergo considerable shrinkage during the polymerization process leading to marginal leakage. In addition, they were having poor wear resistance, high water sorption, and a high coefficient of thermal expansion. Quartz powder was incorporated as a filler to address the inherent drawbacks of the resins. These fillers occupy the spaces between the polymer chains and improve the physical and mechanical properties, which are primarily influenced by the volume fraction of inert fillers [1-5]. However, the early composites were lack of proper bonding between the polymeric resin and the filler particles. In 1962, Dr L. Bowen invented a new dimethacrylate resin, such as Bisphenol A Glycidyl methacrylate (Bis-GMA) and an organosilane coupling agent, which provides a bond between filler particles and the resin matrix [4-6]. This invention led to the evolution in resin-based direct aesthetic restorative materials.

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Composite resins are complex, tooth-colored filling materials that offer excellent esthetic potential and acceptable longevity without the need for extensive tooth preparation, allowing minimally invasive preparation or sometimes no preparation at all. They represent one of many success of modern biomaterial research. However, the early formulations of these resin composite materials had numerous drawbacks such as poor handling characteristics and polymerization shrinkage. To address this, various types of filler particles with different volume fractions have experimented with the resins. This led to the development of maco-filled, small-filled, micro-filled and hybrid composites [4]. Although, these materials showed better improvements compared to earlier versions but not up to the standard. The quest of researchers on improving its properties led to the development of newer versions of composite resins. Therefore, this review focused on discussing various composite resin materials developed in recent years.

2. Recent advances in composites

2.1 Condensable composites or packable composites or polymer rigid Inorganic matrix material (PRIMM)

These are one of the new advancements in posterior composites, developed by Dr Lars Ehrnford of Sweden in 1995. This system is composed of a resin matrix and an inorganic ceramic component. Unlike in conventional composites; in this system, the resin is incorporated into the fibrous ceramic filler network rather than including the filler particles into the composite resin matrix. The filler mainly consists of Aluminium oxide, Silicon oxide glass particles or barium aluminium silicate or strontium glasses. Further, colloidal silica ultrafine particles are also incorporated to control the handling characteristics such as viscosity, resistance to flow, condensability and reduced stickiness [7].

The glass particles are liquified to a molten state, and it is forced through a die to form thin strands of glass fibers with a diameter of approximately 2-3 micrometres. These glass fibers are then reheated to an adequate temperature after pulverizing them into small space particles. This results in the superficial fusion of glass fibers at selected sites (silanation) and forms a continuous network of small chambers or cavities with 2-micrometre dimensions. Resin is then allowed to infiltrate into these spaces or chambers. This concept provides a basis for fabricating packable or condensable posterior composite resin resulted in advantages of better reproduction of occlusal anatomy, better marginal adaptation, ease in achieving a good contact point [8]. The physical and mechanical behaviour of these materials is better than that of hybrid-composites and similar to that of silver amalgam [9]. However, the clinical performance of these materials is identical to that of the hybrid composites [5,10,11]. Condensable composites are indicated in class II cavities.

2.2 Indirect composite resins

The indirect composites such as inlay and onlay systems were developed to address the major clinical problems associated with the direct posterior composite resins. The first generation indirect composite resins were introduced in the 1980s by Touti and Mörmann. Indirect composite resin restorations exhibit superior marginal adaptation, contour, and proximal contact as it is fabricated on a die rather than directly in the cavity preparation [4,8]. The number of highly improved indirect resin restorative systems have been introduced with unusually good properties like wear resistance, esthetics, control over polymerization shrinkage, and marginal adaptation [4].

2.3 Organically modified ceramic oligomers (ORMOCER)

ORMOCER is an acronym for organically modified ceramics. They are considered to be molecule-sized hybrid structures consisting of inorganic, organic copolymers. Organic reactive monomers are bound to inorganic –si-o-si- network. These molecular hybrids consist of, for example, methacrylate-terminated chains grafted on to a central cyclic polysilioxane 2-3nm particles. These nanoparticles are dispersed on a molecular scale [2, 12]. These are high molecular weight, flexible, relatively low viscosity crosslinking molecules. The large spacing between crosslinks resulting from curing produces a low-level polymerization shrinkage, while the inorganic network provides abrasion resistance through its glass-like structure and low water sorption due to its hydrophobicity [2,12,13].

Because of their unique composition, ORMOCER-based dental materials offer characteristic advantages in comparison to conventional composites. They include;

limited cure shrinkage, very high biocompatibility, good manipulation properties, and excellent esthetics. These materials are indicated for class-I to V cavities, veneering of discoloured anteriors, repair of veneers, core build-up, orthodontic bonding adhesive, indirect inlays, and reconstruction of traumatically affected anteriors [2,12].

2.4 Fiber Reinforced Composites (FRC)

Fiber reinforcement has further increased the potential uses of composites within restorative dentistry. Glass fibers, carbon fibers polyethylene fibers, aramid fibers, etc., are the most commonly used fibers in dental composites [3]. These fibers can be oriented in different directions; unidirectional, weave type, mesh type, etc., in the resin matrix to improve the physical and mechanical properties of composites. The durability of the fiber-reinforced composites mainly depends on essential factors including fiber loading within the resin, adhesion of fibers to the matrix, the orientation of fibers, volume of fibers in composite matrix, etc., [3]. Silane coupling agents are commonly used to provide bonding between resin matrix and fibers [6]. These fiber reinforced composites have shown improved strength and stiffness and improved wear resistance. Their main applications are in periodontal splinting/ post-trauma splint, fixed partial dentures, reinforcing or repairing dentures, fixed orthodontic retainers, root posts, and reinforced biomedical implants [3, 14]. Mohan M et al. (2019) compared the fracture toughness of fiber-reinforced composites with micro-hybrid and nano-hybrid composites. They also reported that the FRCs exhibited more fracture toughness compared to the other materials. They also suggested that these are the choice of the restorative materials for posterior teeth [15].

2.5 Flowable Composites

These composites were developed mainly to improve the handling properties for composites resins. These composites contain less filler content of traditional hybrid composites with the same filler size. The resin matrix was increased to reduce the viscosity of the mixture. Since the filler content was reduced, they lack adequate strength to withstand high stresses [16] Due to increase in resin content; these composites show more polymerization shrinkage [16] and less elastic moduli and its use in high-stress bearing areas is questionable [17-19]. However, these materials wet the tooth surface better and flows easily into the every undercuts and also forms in thin layers reducing the formation of air pockets at the tooth-restoration interface [16, 20]. In addition, flowable composites exhibit superior chemical curing properties compared to the conventional composites.this is because of their lower filler loading which would decrease the light scattering through material and provide a better degree of conversion depth. Further, these materials contain a germanium based photoinitiator which is more effective and has a much higher significant yield compared to camphorquinone amine system [21]. Baoudi K et al. (2015) suggested in a systematic review that the flowable composites are the promising aesthetic restorative materials for the future and will become markedly useful material in various aesthetic restorative procedures [22].

2.6 Self-healing or self-repairing composites

Materials usually have a limited shelf-life and degrade over time due to different physical, chemical or biological stimuli. But researchers have developed materials which can repair themselves. The self-healing and self-repairing composite is an epoxy-based system which contains resin-filled microcapsules. These microcapsules may be destroyed and release the resin when the epoxy resin undergoes crazing. The resin subsequently fills these cracks and reacts with a Grubb's Catalyst that is dispersed in the epoxy composite. This may eventually polymerize the resin and repair the crack [23].

2.7 Stimuli response materials

These are also called “smart materials”. The properties of these materials essentially depend on external stimulus such as temperature, pH, mechanical stress, moisture, etc., These composite materials release fluoride, calcium, and hydroxyl ions into the surroundings of the filling depending on the pH. These materials release, especially when the pH is less than 5.5, a significant number of ions than that at the neutral pH. Therefore, it provides additional caries protection [23-25].

2.8 Bellglass HP

Bellglass HP is an indirect restorative material which was introduced in 1996 by Belle de St. Claire. These materials have increased polymerization rate as they are cured under pressure (29 PSI) at an elevated temperature of 1380C and in the presence of nitrogen gas. The elevated temperature and the increased atmospheric pressure not only increases the rate of curing but also reduces vaporization potential of the monomers. Wear resistance of the Bellglass HP is increased due to curing in the presence of nitrogen gas. In addition, the rate of curing is also improved as nitrogen gas provides an oxygen-free environment. Oxygen acts as polymerization inhibitor and delays the polymerization reaction and also reduces the translucency of composites [26, 27].

2.9 Self-adhering composites

Self-adhering composites are also called as compo-bonds. Self-adhering flowable composite combines the advantages of both dental adhesives and restorative materials technologies (8th generation) in a single product [28]. The first compo-bond was introduced in 2009 by (Kerr Corp). Compo-bonds have the benefits of self-etching dentin bonding agents and nano-filled resins. They eliminate the precursory bonding stage necessary to adhere, resin to tooth substrate, thus reducing the chances of postoperative sensitivity. These composites have properties similar to the conventional flowable composites. They also have the properties of 7th generation of dentin bonding agents; thus, they act as shock absorbers beneath the resin-based composite restoration. As compo-bonds function both as dentin adhesive and resin restorative both as dentin adhesive and resin restorative material, a longer curing time is necessary to ensure that both constitutes are fully polymerized [29].

2.10 Art glass

Art glass is a nonconventional dental polymer marketed since 1999. It is widely used in making indirect restorations such as inlays, onlays, and crowns. These materials exhibit improved wear resistance and other physical and mechanical properties due to the greater level of crosslinking. The fillers used are radiopaque Barium glass with an average particle size of 0.7 micrometres and colloidal silica, which enhance the handling characteristics to a greater extent. A special light curing unit such as Xenon stroboscopic light-curing device with the emission ranges from 300-500 nm is used for curing of these resins. The advantages of these materials include high wear resistance compared to traditional composites, good marginal adaptation, esthetics, and superior proximal contact [26,27].

2.11 Nanocomposites

Nanotechnology consists of reducing components of material to nanometric scale for use in a new material, to improve the final characteristics. In nano-filled resins, the inorganic nano-fillers are added to organic resin matrix to have the strength of inorganic material and flexibility and toughness of organic material [30,31]. These composites have approximately 60% volume filler loading, making the nano-filled resins as strong as the hybrid and micro-hybrid resins. The nanocomposites have nanofillers that contain nano-modifier such as the nanomers and nanoclusters that result in increased flexural strength, increased modulus of elasticity, improved wear resistance and hardness, decreased polymerization shrinkage and enhance polishability of resin. Nanofillers may include colloidal silica or ormocers, such as Inceram X from Dentsply. Similar particles may be used in resin-based bonding systems. Nanoparticle filled dental particles may show an enhanced fracture toughness and adhesion to tooth tissue [2,4,30,31].

Nano filled, and nanohybrids are commonly available nanocomposites. The average particle size of Nano-filled ranges from 1-100 nm, whereas nanohybrids are comprised of larger particles of ranging from 0.4 to 5 microns. The properties of these composites are size and shape determinant. These nanofillers present superior properties than nanohybrids [1, 30].

2.12 Antimicrobial materials

Antimicrobial agents and antibiotics were introduced into composites to provide antimicrobial activity [24,32]. Recently, antimicrobial nanoparticles such as quaternary ammonium polyethylenimine [24,32], Silver [33-36], Zinc Oxide [37-39], Titania [40] and Chitosan [41] nanoparticles were experimented with composites to impart antimicrobial characteristics. Microbes may be killed on direct contact with these materials or through leaching of the antimicrobial materials into the oral environment. Silver and Titania particles are commonly used into dental particles to increase antimicrobial property and enhance biocompatibility. Fatemeh K *et al.* (2017) reported that the adhesives incorporated with silver nanoparticles showed greater bond strength. However, it was also reported that the bond strength was dependent on the composition of the adhesive resins [36].

2.13 Calcium phosphate nanoparticles

Calcium phosphate such as Hydroxyapatite phosphate, anhydrous calcium phosphate, tetra calcium phosphate and dicalcium phosphate anhydrous have been used as fillers. To make mineral releasing dental composites. The incorporation of these particles improves stress-bearing capacity and ion release that inhibit dental caries [42,43].

2.14 Bioactive glass nanoparticles

These have excellent regenerative properties in mineralised tissues. The high surface area of nanoparticles may facilitate the dissolution of ions from the gas and thus accelerate dentin mineralization. These nanoparticles induce the formation of apatite in dentin [44].

Conclusion

The science and technology of composites have significantly improved compared with their predecessors. Although composites have not evolved to the point of totally replacing amalgam, they have become a viable substitute for amalgam in many clinical situations. As we know the development of high-performance restorative materials is essential to the success of dental treatment but with composite resin materials, problems still exist. However, new expanding resins, nanofiller technology, and improved bonding systems have the potential to reduce these problems. With increased patient demands for esthetics, the use of composite materials for restorations will continue to grow; and so will the area of research to combat the existing limitations of composites as a restorative material.

References

1. Anusavice KJ. Restorative Resins (in) Philips' Science of Dental Materials. Elsevier, India. 11th edition. 399-442.
2. Rama Krishna Alla. Restorative Materials: Composite Resins, (In) Dental Materials Science, Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India 2013; 130-48.
3. Alla RK, Sajjan S, Ramaraju AV, Ginjupalli K, Upadhya N, Influence of fibre reinforcement on properties of Denture base resins, J Biomater Nanobiotech, 2013;4(1): 91-97.
4. Ravi RK, Rama Krishna Alla, Shammas M, Devarhubli A, Dental Composite – A Versatile Restorative Material: An Overview, Ind J Dent Sci., 2013; 5(5):111-115.
5. Hervás-García A, Martínez-Lozano MA, Cabanes-Vila J, Barjau-Escribano A, Fos-Galve P. Compositeresins. A review of the materials and clinical indications. Med Oral Patol Oral Cir Bucal 2006; 11:215-20.
6. Konakanchi A, Alla RK, Guduri V. Silane Coupling Agents – Benevolent Binders in Composites, Trends Biomater. Artif. Organs, 2017; 31(3): 102-107.
7. Faras R, Pujar M, Lahiri A, Havaldar SC, Shetye SA. Recent advances in composite resins – A review. Paripex-Ind J Res. 2018;7(8): 93-94.
8. Prachi Singh, Nitesh Kumar, Richa Singh, Kamini Kiran, Shailesh Kumar. Overview and recent advances in composite resin: A review. Int J Sci Stud. 2015; 3(9): 169-172.
9. Suzuki S. Does the wear resistance of packable composite equal that of dental amalgam?. J Esthet Restor Dent 2004;16:355-65.
10. de Souza FB, Guimaraes RP, Silva CH. A clinical evaluation of packable and microhybrid resin composite restorations: one-year report. Quintessence Int. 2005;36:41.
11. Benly P. Recent Advances in Composite – A Review. J Pharm Sci Res. 2016;8(8): 881-883
12. Sivakumar A, Valiathan A. Dental Ceramics and Ormocer Technology – Navigating the future, Trends Biomater Artif Organs 2006; 20: 40-3.
13. Leinfelder KF. New developments in resin restorative systems. J Am Dent Assoc 1997; 128: 573-81.
14. Freilich MA, Meiers JC, Duncan JP, Goldberg AJ. Fibrereinforced Composite in Clinical Dentistry. Chicago: Quintessence Publishing Co., Inc.; 2000.
15. Mohan M, Ramciya KV, Justin Baby. Comparison of Fracture Resistance of Teeth Restored with Microhybrid, Fiber Reinforced And Nanohybrid Composite Resins An In-Vitro Study. Int J Recent Sci Res. 2019:10(08):34460-34465.
16. Olmez A, Oztas N, Bodur H. The effect of flowable resin composite on microleakage and internal voids in class II composite restorations. Oper Dent 2004;29:713-9.

17. Cohen R. The expanded use of improved flowable composite. Dent Town, 2008; 64: 25-35.
18. Attar N, Tam LE, McComb D. Flow, strength, stiffness and radiopacity of flowable resin composites. J Can Dent Assoc, 2003; 69: 516-21.
19. Jai Ganesh I, Vasanthakumari A, Vivek Reddy, Vivek K, Lokesh S. Revolutionary excellence of composite resins - A review. WJPMR. 2018,4(9), 116-119.
20. Gupta R, Tomer AK, Kumari A, Perle N, Chauhan P, Rana S. Recent advances in bulkfill flowable composite resins: A review. Int J App Dent Sci. 2017;3 (3):79-81.
21. Jaya Singh, Rajkumar B, Boruah LC, Gupta V, Akanksha Batt. Bulk fill composites in dentistry- A review. Ind J Conser Endodont. 2019;4(1):9-13.
22. Baroudi K, Rodrigues JC, Flowable Resin Composites: A Systematic Review and Clinical Considerations, J Clinical Diagnos Res. 2015:9(6): ZE18-ZE24
23. Badami V, Ahuja B. Biosmart materials: Breaking new ground in dentistry. Sci World J. 2014: 986912.
24. Yeli M, Kidiyoor KH, Nain B, Kumar P. Recent advances in composite resins - A review. J Oral Res Rev. 2010;2:8-14.
25. Jandt KD, Sigusch BW. Future perspectives of resin-based dental materials. Dent Mater 2009; 25: 1001-1006.
26. Nandini S. Indirect resin composites. J Conserv Dent, 2010; 13: 184-94.
27. Lutz F, Phillips RW. A classification and evaluation of composite resin systems. J Prosthet Dent, 1983;50: 480-8.
28. Shaalan OO, Abou-Auf E, El Zoghby AF. Clinical evaluation of self-adhering flowable composite versus conventional flowable composite in conservative Class I cavities: Randomized controlled trial. J Cons Dent. 2018;21(5):485.
29. D'Alpino P.H.P., da Rocha Svizero N., Carrilho M. (2018) Self-Adhering Composites. In: Miletic V. (eds) Dental Composite Materials for Direct Restorations. Springer, Cham.
30. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc. 2003;134(10):1382-90.
31. Beun S, Glorieux T, Devaux J, Vreven J, Leloup G. Characterization of nanofilled compared to universal and microfilled composites. Dent Mater. 2007;23(1):51-9
32. Beyth N, Yudovin-Farber I, Bahir R, Domb AJ, Weiss EI. Antibacterial activity of dental composites containing quaternary ammonium polyethylenimine nanoparticles against Streptococcus mutans. Biomaterials 2006;27:3995-4002
33. das Neves PBA, Agnelli JAM, Kurachi C, de Souza CWO. Addition of Silver nanoparticles to composite resin: Effect on Physical and Bactericidal Properties In Vitro. Braz Dent J. 2014; 25(2):141-145.
34. Farahani A, Beyrami A, Piri H, Naghizadeh A, Imani H, Farahani MH. Evaluation of Antibacterial Properties of Resin Composites Containing Silver Nanoparticles on Streptococcus Mutans. J Dent Oral Health. 2018; 5: 1-6.
35. Ai M, Du Z, Zhu S, Geng H, Zhang X, Cai Q, Yang X. Composite resin reinforced with silver nanoparticles-laden hydroxyapatite nanowires for dental application. Dent Mater. 2017;33(1):12-22.
36. Fatemeh K, Mohammad Javad M, Samaneh K. The effect of silver nanoparticles on composite shear bond strength to dentin with different adhesion protocols. J App Oral Sci. 2017;25(4):367-73.
37. Sevinç BA, Hanley L. Antibacterial Activity of Dental Composites Containing Zinc Oxide Nanoparticles. J Biomed Mater Res. B. Appl Biomater. 2010; 94(1): 22–31.
38. Hojati ST, Alaghemand H, Hamze F, Babaki FA, Rajab-Nia R, Rezvani MB, Kaviani M, Atai M. Antibacterial, physical and mechanical properties of flowable resin composites containing zinc oxide nanoparticles. Dent Mater. 2013;29(5):495-505.
39. Angel Villegas N, Silvero Compagnucci MJ, Sainz Ajá M, Rocca DM, Becerra MC, Fabián Molina G, Palma SD. Novel Antibacterial Resin-Based Filling Material Containing Nanoparticles for the Potential One-Step Treatment of Caries. Journal of healthcare engineering. 2019; Article ID 6367919, 8 pages.
40. Sodagar A, Akhoundi MS, Bahador A, Jalali YF, Behzadi Z, Elhaminejad F, Mirhashemi AH. Effect of TiO2 nanoparticles incorporation on antibacterial properties and shear bond strength of dental composite used in Orthodontics. Dental Press Journal of Orthodontics. 2017;22(5):67-74.
41. Sodagar A, Bahador A, Jalali YF, Gorjizadeh F, Baghaeian P. Effect of Chitosan Nanoparticles Incorporation on Antibacterial Properties and Shear Bond Strength of Dental Composite Used in Orthodontics. Iran J Ortho. https://doi. org/10.17795/ijo-7281. 2016.

42. Xu HH, Moreau JL, Sun L, Chow LC. Nanocomposite containing amorphous calcium phosphate nanoparticles for caries inhibition. Dental Materials. 2011 Aug 1;27(8):762-9.
43. Xie XJ, Xing D, Wang L, Zhou H, Weir MD, Bai YX, Xu HH. Novel rechargeable calcium phosphate nanoparticle-containing orthodontic cement. International journal of oral science. 2017;9(1):24.
44. Polini A, Bai H, Tomsia AP. Dental applications of nanostructured bioactive glass and its composites. Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology. 2013;5(4):399-410.

Review Article *International Journal of Dental Materials 2019; 1(2)*

Advances in alginate impression materials: a review

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ABSTRACT

Alginate is an irreversible elastic hydrocolloid which has various applications in dentistry. The applications of alginates include making impressions of edentulous and partially edentulous arches, duplication of casts, and for making study models. Alginates possesses numerous vital properties such as hydrophilicity, ability to record finer details, elastic recovery and inexpensive; makes this material widely used in dentistry. Though alginate is the most commonly used impression material, it has some inherent disadvantages. Alginates contain low-density fine filler particles, which may arise in the form of dust and inhalation these dust particles may cause respiratory problems. Further, they are highly dimensionally unstable due to syneresis & imbibition. Besides, alginates do not adhere to non-perforated trays, low viscosity resulting in gag reflex in some patients, and the inability to identify the correct consistency to load. Several modifications were made in the composition of conventional alginates to address their shortcomings. This article reviewed various recent advances in the alginate impression materials and their performance.

1. Introduction

Alginate is an elastic and irreversible hydrocolloid impression material, which has been using in dentistry for many years. Alginate impression materials is essentially an alginic acid, which is obtained from brown seaweed (marine plant). Alginate is a high molecular weight linear polymer of anyhydro-D-mannuronic acid [1]. Alginate is a linear acidic polysaccharide comprising β-d-mannuronate (M) and its C-5 epimer α-l-guluronate (G). In alginate polymers, the residues are arranged in a block structure of a homopolymer (polymannuronate (PM) or polyguluronate (PG)) or heteropolymer (a mixed sequence of these residues). The properties of alginate depend on the degree of polymerization and the ratio of mannuronan (M) and Guluronan blocks (G). As shown in figure 1, the mannuronan chains are stretched

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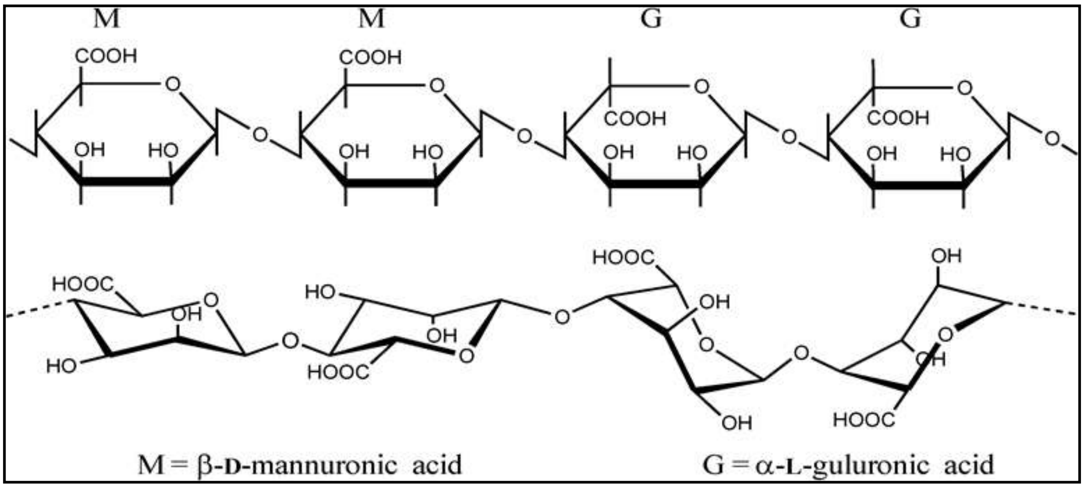

Figure 1. Structure of Alginic acid

and flat, which are more flexible compared to guluronan blocks. Guluronan blocks react with calcium and produce a strong and brittle gel, whereas mannuronan block produces weaker and elastic [2,3].

Alginate impression material contains soluble alginic acid as a principle reactive ingredient. The average molecular weight of alginic acid is in the range of 32000 – 200,000. The molecular weight of the alginic acid influence the viscosity of the sol. The more the molecular weight more will be the viscosity of the sol and vice versa [3]. The composition of alginate impression materials is detailed in table 1.

Alginate is widely used, though this material is not ideal in every aspect, for making edentulous and partially edentulous impressions for the fabrication of complete and removable partial dentures respectively. Alginate impression materials are easy to use, records fine details, and cost-effective compared to its counterpart elastic impression materials [1].

However, alginate impression materials contain fine diatomaceous earth fillers particles. These fillers rise in the form of dust on the opening of the alginate storage container's lid due to their lack of density. Alginates are highly hydrophilic tend to absorb water or moisture, leading to dimensional changes. Further, their low viscosity may result in the gag reflex in patients. It is necessary to use perforated trays to make impressions with these materials as they do not adhere well to the impression trays [1-4].

S.No.	Ingredient	Functions
1.	Soluble alginate	Main reactive ingredient.
2.	Calcium sulfate dihydrate	Reactor
3.	Trisodium phosphate	Retarder
4.	Diatomaceous earth and Zinc Oxide	Fillers
5.	Potassium-titanium fluoride	Gypsum hardener
6.	Flavoring agents	Provide appropriate taste
7.	Colour pigments	Provide characteristic colour.

Table 1. Composition of alginate impression material

2. Evolutionary changes in the alginate impression material

2.1 Dustless alginates

These materials were developed to eradicate silicosis, which is caused by the presence of diatomaceous earth in the form of fillers in conventional alginate impression materials. These fillers are low-density siliceous fibers with dimensions of 3-20 µm and more potential carcinogens. These fibers will raise in the form of dust during usage and inhalation of those fibers may cause respiratory problems [1].

An attempt was made to increase the density of siliceous fibers by coating them with dedusting agents like glycerin, glycol, polyethylene glycol, and polypropylene glycol [1,3]. Recently, sepiolite (natural mineral fiber-containing magnesium silicate -20%) was added to the alginate materials that helps in holding alginate particles together to prevent the leaping of dust particles. This reduced the dust generation from alginate impression materials during dispension. Numerous manufacturers also incorporated tetrafluoroethylene to avoid the dust particles raising by forming the cobweb during mixing [5].

2.2 Alginate in the form of two-paste system

Alginates were developed in two-paste systems to prevent the contamination of powder, and inconsistency in dispensing a certain amount of powder. It consists of base paste and catalyst paste. The base paste contains soluble alginate, water, and fillers, whereas catalyst paste contains calcium salts, viscous liquids like liquid paraffin and magnesium hydroxide as a pH stabilizer [6-8].

2.3 Chromatic alginates (Alginates with color indicators)

The problem observed among some of the undergraduate students is difficulty in identifying the ideal consistency of alginate material during manipulation. Various color indicators were added to the alginate impression materials to identify the different stages of manipulation. These color indicators change the color of the alginate mix as setting reaction taking place due to the change in the pH [1,3,9]. This change in the color of the alginate mix facilitates identification of the ideal consistency to load it into the tray and make accurate impressions.

2.4 Self-disinfected alginates

Disinfection of impression is an essential and necessary procedure in dental practice to prevent cross-infection and safety of patients, dentists, and dental personnel. Disinfection of impression should prevent spreading of infection from dental clinic to dental laboratory technician, other patients, and dental auxiliaries. Mantena SR *et al.* (2019) reviewed various methods employed to disinfect dental impressions. It was reported in the literature that the conventional disinfection procedures such as immersion and spraying methods which may lead to the unwanted dimensional changes in the alginate impression as they were hydrophilic [10].

Numerous researchers developed alginate impression materials by incorporating disinfectant agents in their compositions. The disinfectant materials incorporated include quaternary ammonium compounds, chlorhexidine, bisquanidine compounds, chlorhexidine, didecydimethy ammonium chloride [11-14]. Addition of disinfecting agents into the impression materials eliminates separate disinfection of the impression immediately after removing it from the patient’s mouth.

Recently, researchers have experimented incorporating different antimicrobial nanoparticles into alginate impression materials. Several studies have reported that the addition of silver nanoparticles is more effective against S. aureus, Lactobacillus acidophilus, Actinomyces viscosus, and Pseudomonas aeruginosa [15-17]. Particle size and concentration of the silver nanoparticles are the essential factors that play a significant role in antimicrobial activity in alginate impression materials. It was suggested that the silver nanoparticles with the average particle size of 80–100 nm impart superior antimicrobial property to the alginate in a concentration-dependent manner than the finer nanoparticles [15,16]. It was also reported that the flow, gelation time and strength of alginate impression materials were adversely affected by the incorporation of greater than 1.0wt% of silver nanoparticles [15,16]. Several researchers also experimented the antimicrobial efficacy of Zinc oxide and Copper oxide nanoparticles in alginate impression materials. They reported that these nanoparticles were also proved to be effective self-disinfecting agents for alginate impression materials with no adverse effect on physical and mechanical properties [18].

2.5 Extended pour alginates

Due to syneresis and imbibition, it is unable to store the alginate impression for a longer duration. Attempts made by the manufacturers to address this problem led to the development of two new alginate materials such as CAVEX Color Change (Darby Dental Supply, USA) and Extend a Pour (Dux Dental Products). Cavex color change material can be preserved for about 100hrs and extend a pour can be preserved up to 4 weeks [5,19-22].

2.6 Alginate with polyacrylamide incorporation

On mixing with water, conventional alginates may tend to form a grainy mass with lumps of unmixed material as the water does not wet the powder easily. A thickening and stabilizing agent such as 0.01-0.25wt% polyacrylamide (molecular weight-200,000 to 6,000,000) were incorporated into the conventional alginates resulted in improving the mixing characteristics, and the formation of smooth alginate sol with water [3, 23, 24].

2.7 Storage medium for alginates

Traditional alginates, being hydrocolloid, are dimensionally unstable due to syneresis and imbibition. Hence, it is necessary to pour the gypsum cast as early as possible after the impression is removed from the mouth [3,25]. A storage solution is now available to store the alginate impressions without any dimensional changes. It was reported that storage of alginate impression in that solution did not show significant dimensional changes up to 100 hrs [3,26].

2.8 To improve the wettability of alginate powder by water

In general, water has less ability to penetrate the conventional alginate powders during mixing. Hence, the formation of a smooth and uniform mix requires longer mixing time with a resultant decrease in the working time. To address this, alginate impression materials were incorporated with hydrophobic materials and surfactants such as polyoxyethylene alkyl phenyl ether, Polyoxyethylene/polyoxypropylene alkyl ether, polyoxyethylene alkyl ether. These materials increased the permeation of water into the powder particles that resulted in the formation of sol rapidly with sufficient fluidity [3, 5, 27,28].

2.8 Other modifications

The other disadvantage with the alginate impression materials is its shorter mixing time. Hence, the operator should be skilled enough to mix the alginate material within the shorter mixing time to obtain homogenous consistency and make an accurate impression. Mechanical or automatic mixing devices were developed to address this problem. Mechanical mixing devices give more accurate consistency within a shorter time compared to hand mixing [29,30].

Flavouring agent such as cinnamon, strawberry, peppermint, watermelon, cherry, orange, and spearmint are added to the conventional alginates to improve the patient acceptance and to make the material more pleasant during use in the mouth [3,31].

Recently, tray adhesives were developed for alginate impression materials to accomplish better retention with the non-perforated metal or plastic trays. These tray adhesives are dispensed as liquids which contain polyamide or diethylenetriamine polymer, ester gum and rosin in isopropyl alcohol or an amalgamation of isopropyl alcohol with ethyl acetate. [3,5,32,33].

Conclusion

Alginate impression material is widely used for making the primary impression of edentulous and partially edentulous patients. The recent modifications in the composition of alginate impression material led to the enhancement of handling and clinical performance compared to unmodified alginate.

References

1. Rama Krishna Alla. Dental Materials science, in Impression Materials. 2013, Jaypee Medical Publishers Pvt Ltd., New Delhi, India, 182-190.
2. Anusavice KJ, Shen C, Rawls HR. Philips' Science of Dental Materials in Impression materials. 12th Ed., Elsevier Science, USA, 2013; 171-176.
3. Srivastava A, Aaisa J, Kumar TAT, Ginjupalli K, Upadhya NP. Alginates: A Review of Compositional Aspects of Dental Applications. Trends Biomater. Artif. Organs. 2012; 26(1): 31-36.
4. Sakaguchi RL, Powers JM. Craig's Restorative Dental Materials in Replicating materials – Impression and Casting. 13th Ed. Elsevier, USA, 2012; 277-286.
5. Gurleen Kaur, Priyanka Jain, Mudit Uppal, Rohan Sikka. Alginate impression material: from then till now, Heal Talk A Journal of Clinical Dentistry, 2012; 05(2): 2.
6. Pelico, Michael A. Settable alginate compositions. US patent: 4381947, 1984.
7. Winkel Jens, Voigt, Renal. Alginate impression composition. US patent 5306337, 1994.
8. Watanabe, Nobutaka, Kamohara Hiroshi. Two-paste dental alginate impression material. US patent 6509390, 2003.
9. Craig RG. Review of dental impression materials. Adv Dent Res. 1988;2(1):51-64.

10. Mantena SR. Mohd I, Dev KP, Suresh Sajjan MC, Ramaraju AV, Bheemalingeswara Rao D. Disinfection of Impression Materials: A Comprehensive Review of Disinfection Methods. Int J Dent Mater. 2019; 1(1): 07-16.
11. King BB, Norling BK, Seals R. Gypsum compatibility of antimicrobial alginates after spray disinfection. J Prosthodont.1994;3(4):219-227.
12. Talyor RL, Wright PS, Maryan C. Disinfection procedures: their effects on dimensional accuracy and surface quality of irreversible hydrocolloid impression materials and gypsum casts. Dent Mater. 2002; 18(2): 103-110.
13. Gribi HK. Algin based dental impression material containing biocidal component, US patent 4836853, 1989.
14. Badrian H, Ghasemi E, Khalighinejad N, Hosseini N. The effect of three different disinfection materials on alginate impression by spray method. ISRN Dent. 2012;2012: Article ID 695151.
15. Ginjupalli K, Alla RK, Tellapragada C, Gupta L, Perampalli NU. Antimicrobial activity and properties of irreversible hydrocolloid impression materials incorporated with silver nanoparticles. J Prosth Dent. 2016;115(6):722-8. DOI:
16. Ginjupalli K, Shaw T, Tellapragada C, Alla R, Gupta L, Perampalli NU. Does the size matter? Evaluation of effect of incorporation of silver nanoparticles of varying particle size on the antimicrobial activity and properties of irreversible hydrocolloid impression material. Dent Mater. 2018;34(7): e158-65.
17. Jafari A, Bakhtiari R, Shahabil S, et al. Antimicrobial activity of irreversible hydrocolloid impression against oral microorganisms. Basic Appl Sci Res. 2013;3: 397-401.
18. Ginjupalli K, Alla RK, Shaw T, Tellapragada C, Gupta LK, Upadhya PN. Comparative evaluation of efficacy of Zinc oxide and Copper oxide nanoparticles as antimicrobial additives in alginate impression materials. Materials Today: Proceedings. 2018;5(8):16: 258-66.
19. Jamani KD. The effect of pouring time and storage condition on the accuracy of irreversible hydrocolloid impressions. Saudi Dent J.2002; 14(3): 126 -30.
20. Imbery TA, Nehring J, Janus C, Moon PC.Accuracy and dimensional stability of extended-pour and conventional alginate impression materials. J Am Dent Assoc. 2010;141(1):32-9.
21. Walker MP, Burckhard J, Mitts DA, Williams KB, Dimensional changes over time of extended storage alginate impression materials. Angle Orthod.2010;80(6): 1110-5.
22. Rohanian A, Ommati Shabestari G, Zeighami S, Samadi MJ, Shamshiri AR. Effect of storage time of extended-pour and conventional alginate impressions on dimensional accuracy of casts. J Dent (Tehran). 2014;11(6):655–664.
23. Pellico, Michael A (Los Angeles, CA). Settable alginate compositions containing polyacrylamide. U.S. Patent: 4468484, 1984.
24. Pellico, Michael A (Los Angeles, CA). Dental impression composition containing finely sized polyacrylamide. U.S. Patent: 4626558, 1986.
25. Hisako Hiraguchi, Masahiro Kaketani, Hideharu Hirose, Takayuki Yoneyama. The influence of storing alginate impressions sprayed with disinfectant on dimensional accuracy and deformation of maxillary edentulous stone models. Dent Mater J. 2010; 29(3): 309–315.
26. Mary P Walker, Jason Burckhard, David A Mitts, Karen B Williams. Dimensional change over time of extended-storage alginate impression materials. Angle Orthod. 2010;80(6):1110-5.
27. Hiroshi Kamohara, Hiroki Morita. Dental alginate impression material composition. United states patent application. 20080057465, 2008.
28. Hiroshi Kamohara, Hiroki Morita. Dental alginate impression material composition. U.S. Patent: 7819963, 2010.
29. Nandini VV, Venkatesh KV, Nair KC. Alginate impressions: A practical perspective. J Conserv Dent. 2008;11(1):37–41. doi:10.4103/0972-0707.43416
30. Ashley M, McCullagh A, Sweet C. Making a good impression: (a 'how to' paper on dental alginate). Dental Update. 2005;32(3): 169-75.
31. Pierce, Karen A. Alginate flavoring in a powdered form. U.S. Patent: 6251176 2001.
32. Woortman R, Hermans J, Feilzer AJ, Effect of alginate adhesives on bond strength of aginate impression material to stainless steel, Cavex Holand B.V. Haarlem , NL,ACTA, Department of Dental Material Science Amsterdam, NL, 2003. https://www.cavex.nl/nl/content/49-product-files/cases-a-research/611-effects-of-alginate-adhesives-on-the-bond-strength-of-alginate-impression-material-to-stainless-steel
33. Kamohara, Hiroshi Takeo, Makiko, Fukushima, Shouichi (c/o GC Corporation, Tokyo 174-8585). Adhesive composition for alginate impression material, European Patent Application: EP1840180, 2007.

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An overview of dentin bonding agents

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ABSTRACT

From the past, there has been a lot of use of the bonding agents in restorative dentistry. Choosing of bonding systems has become a challenge for the clinicians as there was a lot of advances regarding the usage of bonding agents. Each successive modification in the formulae has led to the classification of the bonding system into many “generations”. During the past few years, these bonding agents have been replaced by the same systems that are used on dentin. This change occurred because of the benefit of bonding resin to both enamel and dentin. Extensive research is still on the way to develop the best adhesive system that can produce reliable and permanent bonds to dentin.

1. Introduction

In dentistry, composites are widely used esthetic restorative materials over six decades [1]. The essential components of dental composites include resin matrix, organic/inorganic fillers, and coupling agents. The composition of dental composites is given in Table 1 [2]. The advantages of dental composite materials include improved strength, abrasion resistance, translucency, ease of application, and polishability. These qualities made them rapidly increased their use in the first decade after being introduced and continues to increase their popularity [3,4]. However, the major disadvantage with the composites is their poor bonding mechanism to the natural tooth. Numerous researchers developed various adhesive resins to provide an appropriate bonding between the composite resin and natural tooth. These early adhesive systems necessitate etching of the natural tooth with certain acids followed by treating with primers and/or conditioning agents [2].

Bonding agents can bring a strong bond between the composite and the tooth structure to withstand mechanical forces and stress. The success of adhesives depends on their ability to adhere to the natural tooth on one side and the composite restoration on the other side. The bonding can be achieved

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S.No.	Ingredient	Functions
1.	Polymer Matrix Eg: Bis GMA, UDMA	Reactive Ingredieant. Possessess high viscosity.
2.	Diluent Eg: TEGDMA	Reduces viscosity of polymer matrix.
3.	Amines	Activator systems
4.	Benzoyl peroxide, Benzoin methyl ethers and Camphoroquinone.	Initiator systems for chemical, UV light and Visible light activated respectively.
5.	Butylated hydroxy toulene	Photoinhibitor
6.	Titania, Alumina etc.,	Optical Modifiers
7.	Fillers Eg: Ground quartz, pyrolytic silica, barium glasses, aluminum silicate, and colloidal silca.	Increases strength and hardness. Reduces CoTE.
8.	Coupling agent Eg: gamma-methacryloxy propyl tri-methoxy silane.	Provides bonding between fillers and polymer matrix.

Table 1. Composition of dental composites

with enamel and dentin, or both by micromechanical interlocking along with chemical bonding. Whereas, the bonding between the composite resin restoration and a bonding agent is attained by copolymerization of the adhesive resin with the resin matrix of composite materials [5,6]. Two different types of bonding agents have been developed. They include enamel bonding agents (EBA)and dentin bonding agents (DBA). The objective of this review is to discuss numerous bonding mechanisms and emphasize the various bonding agents developed in the field of adhesive dentistry to provide bonding with the natural tooth.

1.1 History and evolution

The use of dentin bonding agents markedly reduces the need to provide mechanical retention through dovetails, grooves, undercuts, sharp internal angles which in turn helps in conservation of sound tooth structure. The main reason for the success of aesthetic restorative materials is these adhesive systems[7]. In the late 1960s, Buonocore proposed that boning to dentin was possible[8,9]. In the 1970s, using scanning electron microscope, Eick identified the presence of a smear layer on the dentine surface[10]. He reported that the smear layer is blocking and interfering in bonding to dentin. In the 1980s, the total-etch concept was introduced by the development of etch and rinse systems. In 1982, Nakabayashi demonstrated the concept of hybrid layer formation on the dentin surface [11]. In the 1990s, the three-step total-etch system was developed. In Late 1990s original bonding systems evolved to multi-step systems. Further research leads to simplification of the application procedure to reduce manipulation time [7].

2. Adhesion mechanisms

Adhesion occurs when two, unlike molecules, join together on being brought into contact due to force of attraction between them [2]. The material which is used to produce adhesion is called as an “adhesive” and the substance to which adhesive is applied is called as an “adherent” [2,5,12]. The following are the adhesion mechanisms that are commonly employed in dentistry.

2.1. Mechanical adhesion

The interlocking of the adhesive with irregularities on the surface of the substrate or adherend. If the surface irregularities are responsible for bonding and having dimensions of only a few micrometres, the process is known as “micromechanical attachment”. This is different from macro-mechanical attachment, which forms the basis of retention for many filling materials, using undercut cavities [2].

2.2. Adsorption adhesion

It occurs due to the chemical interaction between the adhesive and the adherend. Forces may be primary (ionic and covalent), secondary (hydrogen, dipole interaction), and vanderwaal's valence forces.

2.3. Diffusion adhesion

Interlocking between mobile molecules such as adhesion of two Polymers.

2.4. Electrostatic adhesion

An electrical double bond layer at the interface of metal with a polymer that is part of the total bonding system.

The bonding mechanism is explained in the following steps [5];

- Dissolution or adequate removal of the smear layer from enamel and dentin.
- Maintenance of the dentin collagen matrix.
- Good wetting.
- Efficient monomer diffusion and penetration.
- Polymerization within the tooth structure.
- Copolymerization with the resin composite matrix.

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3. Bonding agents

EBAs consist of different dimethacrylates from resins of composites like bisphenyl glycidyl methacrylate (bis-GMA) with diluting monomers such as triethylene glycol dimethacrylate (TEGDMA)to control viscosity and to improve wetting. DBAs include etchants, resin monomers, solvents, initiators, inhibitors, fillers, and other ingredients [5,13].

Composition of bonding agents include **[5]*;***

a. Etchant-37% phosphoric acid.
b. Primers-HEMA (2-hydroxyethyl methacrylate) is a widely used primer monomer because of its high hydrophilicity and solvent like nature.
c. Solvents-The most commonly used solvents are water, ethanol, and acetone. Solvent has a specific contribution to improve bond adhesion.
d. Adhesives- Adhesive resins mostly composed of mainly of hydrophobic dimethacrylates such as bis-GMA, TEGDMA, and urethane dimethacrylates (UDMA).
e. Initiators- Polymerization can be initiated through a photoinitiator system consisting of the photosensitizer (e,g., camphoroquinone) and an activator (e.g., tertiary amine) for a self-cure resin system with an initiator such as benzoyl peroxide.
f. Fillers-silica particles.
g. Other ingredients like glutaraldehyde act as desensitizer, paraben used as antimicrobials, fluoride to prevent secondary caries, and chlorhexidine to prevent collagen degradation.

3.1 Chemistry

Chemistry is explained by the formula M-R-X [2,5], where 'M' is the methacrylate group that reacts with the resin matrix, 'R' is the spacer, and 'X' is the functional group for adhesion to tooth tissue.

3.2. Generations of dentin bonding agents

3.2.1 First-generation dentin bonding agents

Buonocore *et al.*, (1956) demonstrated glycerol phosphoric acid dimethacrylate containing resin and cyanoacrylates to bond to acid-etched dentin. Hydrophilic phosphate group from the glycerol phosphoric acid dimethacrylate resin that increases bonding with Ca ions of the hydroxyapatite. The methacrylate groups were then able to bond to restorative acrylic resin [2]. However, the clinical results with these systems were poor. Commercial products of first-generation bonding agents were Scotch bond, Cervident, palakov, etc.

3.2.2 Second generation bonding agents

These systems were introduced in the late 1970s, the majority of these are "halo phosphorous esters" of unfilled acrylic resins such as bis-GMA or HEMA. The Second-generation systems bonded to dentin by ionic bonding to Ca by chlorophosphate groups. They were highly soluble in oral fluids, and moisture from dentin itself could result in debonding from the dentin and causing microleakage. The bond strength to dentin was weak and unreliable [2]. Commercial products from second-generation bonding agents include Clearfil and Prisma Universal Bond.

3.2.3 Third-generation bonding agents

The third generation of adhesive systems used a dentin conditioning step as well as an intermediate primer in conjunction with a bonding agent. The conditioning agents either modify or remove the smear layer before the placement of adhesive resins and attempts have been made to bond chemically with the calcium of dentin. Bowen developed these and used a 2.5% of nitric acid or ferric oxalate dentin conditioner followed by treatments of NTG-GMA and PMDM (Pyromellitic di anhydrate and 2-hydroxy ethyl methacrylate). This system was later modified by replacing ferric oxalate with aluminumoxalate [2].

3.2.3.1 Composition of third-generation bonding systems

- Conditioner: phosphoric acid with aluminum oxalate and nitric acid.
- Mirage bond
  Dentin conditioner: HNO3 and NPG-GMA:2.5%.
  Primer: PMDM.
- Gluma bonding system
  Dentin conditioner: EDTA.
  Primers: HEMA + Glutaraldehyde
- Scotch bond - II.
  Dentin conditioner: Maleic acid and HEMA.
  Primers: BIS-GMA + HEMA.
- Prisma universal bond-III: This is designed to bond both the inorganic and organic parts of dentin.

Till the third-generation, concepts for dentin adhesion were based on bonding via resin tag formation in the tubules of conditioned dentin, the formation of precipitate on pretreated dentin surfaces followed by chemical or mechanical bonding of resin and chemical union to either inorganic or organic components of the dentin [2].The number of clinical steps involved with the newer generation bonding agents was mentioned in table 2 and 3.

3.2.4 Fourth-generation bonding agents

Fourth-generation systems involve three steps which include acid etchant application followed by the application of primer and application of actual bonding agent or bonding resin. A new wet bonding concept was introduced by Kanca [14] and Gwinettet et al. when acetone/alcohol-based primers are applied to demineralised dentine, water diffuses from wet dentine into the acetone, while the acetone diffuses into the demineralised dentine matrix. This chemical dehydration of the collagen network caused by the substitution of water by acetone increases the modulus of elasticity [15-18]. The bond strength of the fourth-generation bonding agents is more compared to the previous generations due to the formation of hybrid layer. It is an acid resistant admixture of polymer and tooth structure components creating a resin-dentin composite. The concept of hybridization is to improve the bond strength and also to provide better dentine seal. This can be achieved by the application of a hydrophilic primer solution that can infiltrate the exposed collagen network forming the hybrid layer. This can markedly reduce microleakage compared to the other bonding systems [13, 19].

3.2.4.1 Commercial products:

- All bond,
- Scotch bond
- Scotch bond multipurpose, 3M, USA.
  Conditioner: Maleic acid–10%.
  Primer: Aqueous solution of HEMA and copolymer.
- PermaQuick, Ultradent.
- ProBond, Dentsply.
- Liner bond-II, Kuraray, Japan.

3.2.5 Fifth-generation bonding agent

Application of fifth-generation bonding agents involves a two-step procedure. A simplified method which combines the primer and adhesives into one application. It includes etching, which is usually done with 30% to 40%phosphoric acid that rinses away, promotes the dissolution of enamel rods thereby creating microporosities that are filled by bonding agents through capillary action and then followed by polymerization of the resin. In this case, phosphoric acid treatment exposes collagen network that is nearly devoid of hydroxyapatite. Bonding occurs by diffusion and infiltration of the resin within the collagen mess, forming a hybrid layer. This hybrid layer will provide micromechanical retention to the restoration. To facilitate clinical use, the fifth-generation system consists of a single bottle system; combined the primer and adhesives into one solution to be applied after etching enamel and dentin simultaneously. Fifth-generation bonding agents generally contain BIS-GMA, HEMA, GPDM, ethanol, barium, aluminum borosilicate glass, fumed silica, sodium, hexafluorosilicate, camphoroquinone [20]. The commercial products of this generation bonding systems include One-Coat Bond (Coltène Whaledent, Switzerland), Prime and bond (Dentsply-Detrey, Germany), Opti bond solo (Kerr, USA), Scotch bond multipurpose single bond -3M (Kuraray, Japan), etc.

Three-step (fourth-generation)	Two-step (fifth-generation)	Two-step (sixth-generation)	One-step (seventh-generation)
1. Etching Apply for 15seconds, rinse 15 seconds gently air dry, while keeping dentin moist.	**1.Etching** Apply for 15 seconds followed by Rinsing for 15 seconds, and gently air-dry while keeping dentin moist.	**1. Etch and Prime** One application without rinsing, gently air-dry.	**1. Etch, Prime, and Bond** Apply 1 to 5 layers without rinsing, gently air-dry, a light cure.
2. Primer application Apply 1 to 5 layers, gently air- dry.	**2.Prime and Bond** Apply 1 to 5 layers, Gently air-dry, a light cure.	**2. Bond** Apply one layer, gently air-dry, a light cure.	
3. Bond agent application Apply one layer of adhesive, followed by light curing.			

Table 2. Outline of clinical steps involved in application of currently available dentin bonding

Generations of bonding agents	Number of components	Number of steps required	Shear bond strength (MPa)
First-generation	2	2	2
Second-generation	2	2	5
Third-generation	2-3	3	12
Fourth-generation	3-5	3	24
Fifth-generation	2	2	25
Sixth-generation	2	1-2	20
Seventh- generation	1	1	25
Eighth-generation	1	1	30 - 38

Table 3. Comparison of the system components, steps required and shear bond strengths of various dentin adhesive systems [2,25].

3.2.6 Sixth-generation bonding agents

These generation systems consist of two different types which are discussed in subsequent sections.

3.2.6.1 Self-etching primer

It is an aqueous solution of 20% of phenyl–p in 30% HEMA for bonding to enamel and dentin simultaneously. The combination of etching and priming steps reduces the working time, eliminates washing out of the acid gel and also eliminates the risk of collagen collapse [2].

3.2.6.2 Self-etching adhesives:

These are all-in-one adhesives contain acidic unreacted monomer that contacts the composite restorative material directly. The etching, priming, and bonding agents together in a single solution are now available commercially. However, the dentin bond strengths of these systems are lower than those obtained with total-etch adhesives [21]. Kallenos *et al.* (2005) [21]and Al-Ehaideb *et al.* (2001) [22] observed no significant differences in tensile bond strength and microleakage between the sixth and fifth-generation systems. Commercial systems available are Adper Prompt L – Pop

(3M ESPE), One – Up Bond F (Tokuyama Dental), Xeno III (Dentsply).

3.2.6.3 Composition

Adper Prompt L – Pop-Adhesive: 2 HEMA, Bis GMA, methacrylate phosphoric Esters, 1,6-hexanidol-dimethacrylate, methacrylate functionalized polyalkenesAcid, camphorquinone, ethanol, water, silica filler, and stabilizer [23].

3.2.7 Seventh-generation bonding agents

The latest generation which combines etch, primer, and bond in a single solution. It is a single-step procedure or "All – in – one". Clinicians consider using one-step, self-etch adhesives are attractive approach since they require reduced and less complex number of clinical steps compared with multistep etch–and –rinse adhesives [2]. Commercial materials available with seventh-generation adhesives are ibond (Heraeus-kulzer), Xeno IV (Dentsply), Optibond All –in –one (Kerr).

The permeability of cured adhesive permits migration of water from underlying dentin and forms water blisters along the composite-adhesive interface. The increase in hydrophilicity encourages better diffusion of the low-viscosity dentin bonding agent into the evacuated spaces created by the acid etching process. As a result, water is incorporated in the shape of trees in the hybrid zone. These blisters can act as stress raisers that lower bond strength of chemical cured composite to dentin. These blisters may be identified as black deposits on immersing in silver nitrate tracer solution. The shelf life and bond strength are decreased due to the water permeability from dentin around the resin tags [24].

3.2.7.1 Composition of seventh-generation adhesives

G-BOND: 4 META, UDMA, phosphate monomer, DMA component, fumed silica filler, acetone, water, photoinitiator.

Clear l S3: MDP, bis-GMA, HEMA, water, ethanol APX-Clearfil.

One Coat7.0: UDMA, HEMA, glycerol-dimethacrylate, polyakenoate methacrylate, and amorphous silica, ethanol.

Xeno V: Bifunctional acrylamides, acrylamide alkyl sulfonic acid, inverse functional phosphoric acid ester, acrylic acid, butylated benzenediol, water, tert-butanol camphoroquinone.

Optibond all in one: Glycerol phosphate dimethacrylate, mono- and di-functional methacrylate esters, water, acetone, ethanol [20].

3.2.8 Eighth-generation bonding agents

In 2010, Voco America introduced Voco futura bond DC as an 8th generation bonding agent, which contains nanosized fillers [25]. Nano-fillers with an approximate particle size of 12 nm are incorporated in these new systems. These nano-fillers facilitate increased penetration of resin monomers and the thickness of the hybrid layer that, in turn, results in improving the mechanical properties of the bonding systems [26,27]. Further, nano-bonding agent solutions with nano-fillers produce better enamel and dentin bond strength, stress absorption, and longer shelf life [28]. These new agents from self-etch generations have acidic hydrophilic monomers which can be easily applied on the moistened and etched enamel [29].

The concentration and the size of the nano-fillers may influence the viscosity of the adhesive resins. It was reported that the filler sizes larger than 15–20 nm and the content with more than 1.0% by weight may increase the viscosity of the adhesives and also results in agglomeration of the fillers on the moistened surface. These clusters can act as flaws that may induce cracks and cause a decrease in bond strength [27]. Numerous studies reported more shear bond strength compared to previous generation bonding agents [30-35]. The shear bond strengths of all eighth-generation bonding agents were described in table 3.

Composition of eight-generation bonding agents includes; a unique combination of three functional monomers (4-META, MDP, and MDTP), notably excluding HEMA, ensures excellent stability and exceptional bond strengths not just to tooth tissue but to all indirect substrates, including composites, precious and non-precious alloys.

3.2.8.1 Commercial products

G-Premio bond, GC Corporation, USA.

All Bond Universal, Bisco Dental, USA.

Conclusion

Dentin bonding agents have dramatically improved in recent years. The major breakthrough has been the "total-etch" technique, in which the smear layer is removed simultaneously with the enamel etching. The primers and bonding agents of multicomponent systems and a combined primer/agent of one-bottle systems provide a dramatic bond to both the collagen and etched hydroxyapatite of the dentin. Although dentin bonding agents are not yet considered "ideal" materials, they are certainly close. The new adhesive systems also can be attributed to their ability to decrease or eliminate postoperative sensitivity, improve the marginal seal, reduce microleakage and enhance the flow of resin into the fissures. The development of functional monomers with strong and stable chemical affinity to hydroxyapatite is, without doubt, a valuable direction to continue for improvement of dental adhesion.

Furthermore, long-term ageing also requires evaluation of its effect in establishing a long-term success of the composite restoration. Hopefully, more controlled clinical trials will be forthcoming, allowing choices of material and technique to be made on a sound scientific basis. Research continues, and each new generation product comes closer to perfection.

Abbreviations

BIS-GMA – Bisphenyl glycidyl methacrylate, HEMA – Hydroxyethyl methacrylate, NPG-GMA – Reaction product of N-phenyl glycin-glycidyl methacrylate, PMDM – Reaction product of Pyromellitic acid and 2-hydroxyethyl methacrylate, UDMA – Urethane dimethacrylate, META – Methacryloxy-ethyl trimellitate anhydride, NTG-GMA – Reaction product of N-P-tolyglycine and glycidyl methacrylate, BPDM – Bimethyldimethacrylate, 5-NMSA – N-methacryloyl-5-aminosalicylic acid, PENTA – Di penta erythritol peta acrylate monophosphate.

References

1. Ravi RK, Rama Krishna Alla, Shammas M, Devarhubli A, Dental Composite – A Versatile Restorative Material: An Overview. Ind J Dent Sci. 2013; 5(5):111-115.
2. Alla RK, Composite Resins (Tooth colored restorative materials) in; Dental Materials Science, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi, India, 2013; 132-148.
3. Ferracane JL. Current trends in dental composites. Crit Rev Oral Biol Med. 1995; 6: 302–18.
4. Fleisch AF, Sheffield PE, Chinn C, Edelstein BL, Landrigan PJ. Bisphenol A and Related Compounds in Dental Materials. Pediatrics 2010; 126:760–8.
5. Anusavice KJ, Shen C, Ralph Rawls H. Bonding and bonding agents; in Phillip's Science of Dental Materials: 12th edition, Elsevier Saunders, USA. 258 - 284.
6. Erickson RL. Surface interaction of dentin adhesive system. Oper Dent. 1992; 5 (suppl): 81-94.
7. Sofan E, Sofan A, Palaia A, Tenore G, Romeo U, Migliau G. Classification review of dental adhesive systems: from the IV generation to the universal type.Annali di Stomatologia2017;VIII (1):1-17 1 s
8. Buonocore M, Marsui A, Gwinnett AJ. Penetration of resin dental materials into enamel surfaces with reference to bonding. Arch Oral Biol. 1968;13 (1):61-70.
9. Swift E Jr, Perdigao J, Heymann H. Bonding to enamel and dentin: a brief history and state of the art. Quintessence Int. 1995;26:95-110.
10. Eick J, Wilko R, Anderson C, Sorensen S. Scanning electron microscopy of cut tooth surfaces and identification of debris by use of the electron microprobe. J Dent Res. 1970;49:1359-1368.
11. Nakabayashi N, Kojima K, Masuhara E. The promotion of adhesion by the infiltration of monomers into tooth substrates. J Biomed Mater Res. 1982;16 (3):265-273.
12. Latta MA, Barkmeier WW. Dental adhesives in contemporary restorative dentistry. DCNA. 1998;42 (4):567-577.
13. Kugel G, Ferrari M. The science of bonding from first to sixth generation. J Am Dent Assoc 2000;131 Suppl:20S-25S.
14. Kanca J, Improving Bond Strength Through Acid Etching of Dentin and Bonding to Wet Dentin Surfaces, J Am Dent Assoc. 1992; 123(9):35-43.
15. Tay FR, Gwinnett AJ, Pang KM, Wei SH. Structural evidence of a sealed tissue interface with a total-etch wet-bonding technique in vivo. J Dent Res.1994; 73(3):629-36.
16. Ruyter IE. The chemistry of adhesive agents. Oper Dent. 1992; 5 (suppl): 32-43.
17. Tay FR, Gwinnett AJ, Pang KM, et al. Resin permeation acid conditioned, moist and dry dentin: A par-

adigm using water free adhesive primers. J Dent Res. 1996;75: 1033-1044.

18. Poptani B, Gohil KS, JaishreeGanjiwale, Manisha Shukla. Microtensile dentin bond strength of fifth- with five seventh-generation bonding agents after thermocycling: An in vitro study. Contemp Clin Dent. 2012;3: S167-71.
19. Alex G. Adhesive considerations in the placement of direct composite restorations. Compend. 2008;1(1):20–25.
20. Kallenos TN, Al-Badawi E, White GE. An in vitro evaluation of microleakage in class I preparations using 5th, 6th, and 7th generation composite bonding agents. J Clin Pediatr Dent 2005; 29: 323–8.
21. Al-Ehaideb AA, Mohammed H. Microleakage of one bottle dentin adhesives. Oper Dent. 2001; 26: 172–5.
22. Hegde & Manjunath. Bond Strength of Newer Dentin Bonding Agents to Altered Dentin Surfaces. Operative Dentistry. 2011;36(2):169-176
23. Pashley DH, Tay FR. The aggressiveness of contemporary self-etching adhesives. Part II: Etching effects on unground enamel. Dent Master. 2001;17(5):430–444.
24. Freedman G. in Contemporary Esthetic Dentistry, Adhesion, Mosby, 2012: 168-213
25. Başaran G, Ozer T, Devecioğlu Kama J. Comparison of a recently developed nanofiller self-etching primer adhesive with other self-etching primers and conventional acid etching. Eur J Orthod. 2009;31 (3):271–275.
26. Kasraei SH, Atai M, Khamverdi Z, KhaleghNejad S. Effect of nanofiller addition to an experimental dentin adhesive on microtensile bond strength to human dentin. J Dent (Tehran) 2009;6(:91–96.
27. Joseph P, Yadav C, Satheesh K, Rahna R. Comparative evaluation of the bonding efficacy of sixth, seventh and eighth generation bonding agents: An in vitro study. Int Res J Pharm. 2013;4(9):143–147.
28. Nogourani MK, NejadSh J, Homayunzadeh M. Sealant Microleakage in Saliva-Contaminated Enamel: Comparison between three adhesive systems. J Dent Sch. 2010; 27(4): 197-204.
29. Townsend RD, Dunn WJ.The effect of saliva contamination on enamel and dentin using a self-etching adhesive. J Am Dent Assoc. 2004;135(7): 895-901.
30. Ibarra, Gabriela Vargas, Marcos A, Armstrong, Steve R, Cobb, Deborah S. Microtensile Bond strength of Self-etching Adhesives to Ground and Unground Enamel. Journal of Adhesive Dentistry. 2002; 4(2): 115-124.
31. Deepa VL, Damaraju B, Priyadharsini BI, Subbarao VV, Raju KR. Comparative evaluation of microshear bond strength of 5th, 6th and 7th) generation bonding agents to coronal dentin versus dentin at floor of pulp chamber: An in vitro Study. J Int Oral Health. 2014;6(5):72–6.
32. Nikhil V, Singh V, Chaudhry S. Comparative evaluation of bond strength of three contemporary self-etch adhesives: An ex-vivo study. Contemp Clin Dent. 2011; 2(2): 94–7.
33. Yaseen SM, Subba Reddy VV. Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth: An in vitro study. J Indian Soc PedodonPrev Dent. 2009; 27(1):33–8.
34. Nair M, Paul J, Kumar S, Chakravarthy Y, Krishna V, Shivaprasad Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An in-vitro study. J Conserv Dent. 2014; 17(1):27–30.
35. Shekar R, Ponnappa KC, Mirdha N, Narula S. To evaluate and compare the shear bond strength of fifth (total etch) generation, sixth (two step, self-etch adhesive) generation and seventh (one step, self-etch adhesive) generation dentin bonding agents. Natl Res Denticon. 2013;2(2):136–43.

Case Report International Journal of Dental Materials 2019; 1(2)

Prosthetic rehabilitation of hemi-mandibulectomy Patient with a definitive prosthesis - a case report

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INFORMATION

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ABSTRACT

"Often the loss reveals the value of things". Surgical removal of odontogenic tumours in the posterior region of mandible leads to discontinuity of mandible. Prosthetic rehabilitation is a successful treatment modality to reconstructive surgeries. Mandibular resection leads to deviated mandibular movements, disfigurement, facial profile asymmetry, dysphagia, impaired speech and, deviation of the mandible towards the surgical site. Treatment modality for oral rehabilitation of patients with mandibular resection includes maxilla-mandibular fixation, implant-supported prosthesis, removable mandibular guide flange prosthesis, and twin occlusion prosthesis. One of the treatment options for the mandibular defect is Cast partial denture prosthesis, whereas surgical reconstruction by implants and grafts is always not feasible in every patient. This clinical report describes rehabilitation of Cantor and Curtis class III mandibular defect using cast partial denture prosthesis following hemi-mandibulectomy.

1. Introduction

Ameloblastoma is a slow-growing benign tumour of the jaw. The most common site for ameloblastoma is mandibular unerupted third molar region. Ameloblastoma of the lower jaw is an aggressive benign tumour of epithelial origin. It is the second most common odontogenic tumour. There are three forms of ameloblastoma, namely peripheral, unicystic, and multicystic tumour. Multicystic ameloblastoma is commonly seen among all and represents 90% of cases [1,2]. Diagnosis mainly from tissue biopsy and characteristic finding on X-ray OPG assist in differentiating between types of ameloblastoma. The challenges in the management of this tumour are to provide complete excision and reconstruction of the bony defect to restore cosmetic and functional outcome to the patient. Restoration of facial form, function, and aesthetics in a patient who has undergone hemi mandibulectomy is a valuable service rendered by a prosthodontist [3,4]. A classification of mandibular defects has been described by cantor and Curtis. Although the classification system is suggested primarily for edentulous patients, it is also applicable to partially edentulous patients. This defect classified based on remaining structures [5,6,7].

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2. Cantor and Curtis classification (figure 1) (1971) [5,6,7]

Class 1: Radical alveolectomy with preservation of mandibular continuity.
Class 2: Lateral resection of mandible distal to cuspid.
Class 3: Lateral resection of mandible involves loss up to the midline.
Class 4: Lateral bone graft surgical reconstruction.
Class 5: Anterior bone graft surgical reconstruction.
Class 6: Resection of the anterior portion of the mandible without reconstructive surgery.

3. Case report

An 18 years old female patient reported to the Department of Prosthodontics (Government Dental College and Hospital, Kadapa) with a chief complaint of missing teeth in lower right teeth region of the jaw. Past dental history revealed that she was diagnosed as Ameloblastoma in the right posterior mandibular region (figure 2). The patient underwent excision of the lesion followed by the resection of a portion of the mandible and placement of avascular fibular bone graft with titanium reconstructive plate was placed to restore the resected defects (figure 3). On extraoral examination showed symmetrical face, concave profile. On intraoral examination revealed that knife-edge ridge with shallow sulcus depth and partially edentulous fourth quadrant teeth (figures 4 and 5). Based on the clinical situation, a removable cast partial denture was planned.

4. Clinical procedure

The patient was evaluated for the fabrication of a cast partial removable partial denture prosthesis. Primary impression was made, and the diagnostic cast was prepared. Surveying was done to assess the number of undercuts on primary abutments and to assess the Path of insertion and removal of the prosthesis. The Removable partial denture includes occlusal rest seats on the 34,35,36 teeth region. The occlusal rest seats were prepared on the distal marginal ridge and the mesial marginal ridge on the first and second premolars and the first molar respectively. The Major connector was a lingual plate, and an I-Bar placed on the 31 teeth and Minor connector supporting the occlusal rim was meshwork type which will be replaced by denture bases with teeth at a later stage. The Direct retainer planned was embrasure clasp on the second premolar and molar teeth whereas simple circlet clasp in the first premolar region. After mouth preparation, the secondary impression was made using Poly vinyl siloxane putty (Aquasil -Addition Silicone) and Light bodied (Aquasil -Addition Silicone) elastomeric impression material using putty wash technique (figure 6). The master cast was poured using type IV die stone. On the master cast, surveying was done (figure 7).

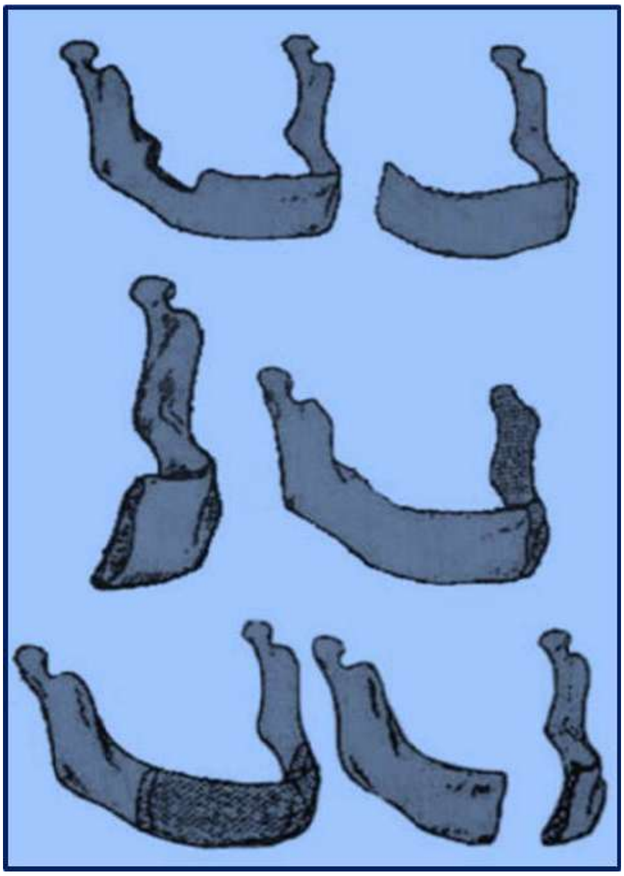
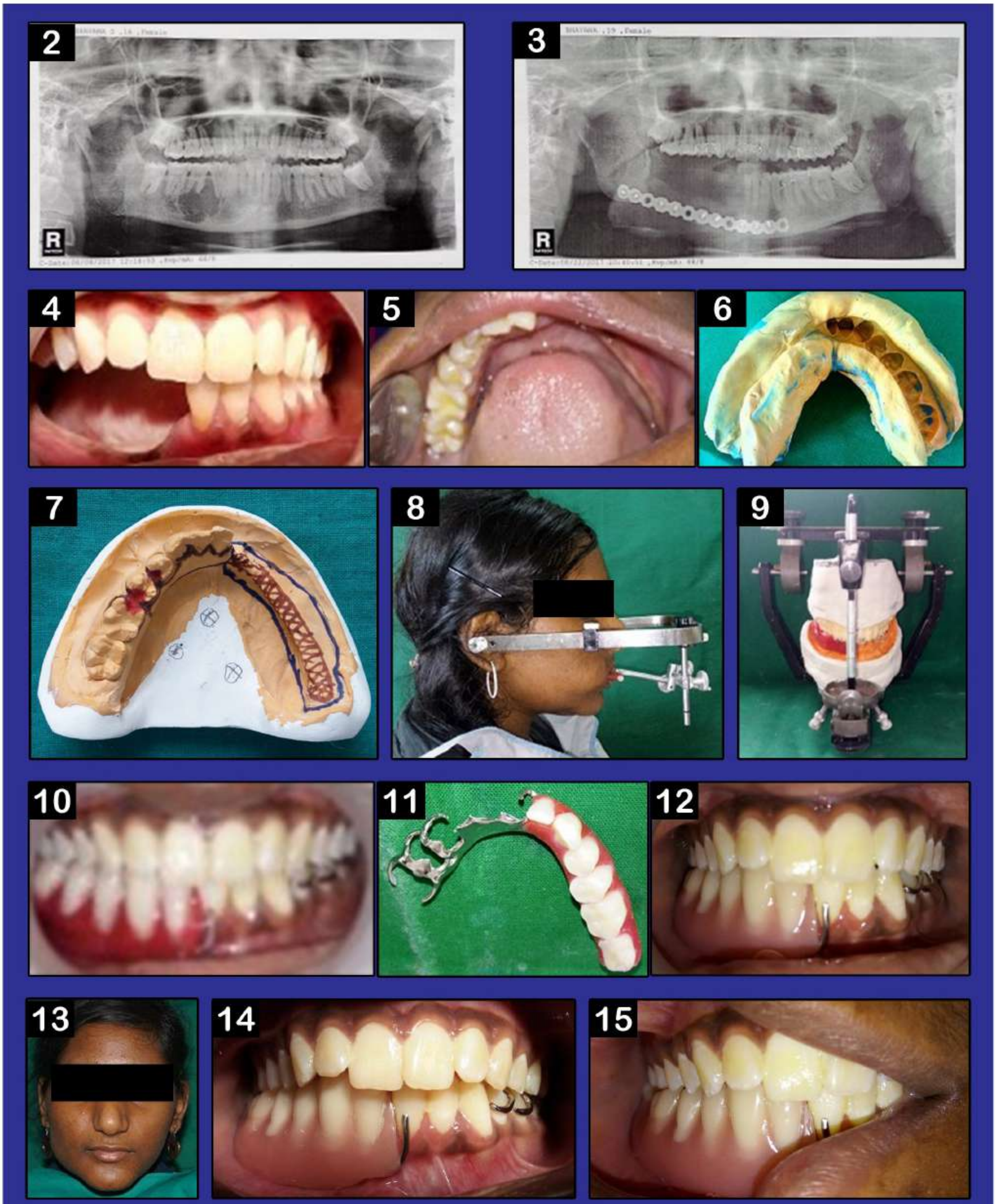


Figure 1. Cantor and Curtis classification of mandibular defects

Planned Block out procedure was carried out and cast duplicated using agar (Castogel, BEGO). Ethyl silicate bonded investment material (Wirovest) was used to obtain a refractory cast over which wax pattern was adapted. The casting was done to obtain a metal framework, which was then tried in the patient mouth for fit, over which modelling wax was adapted to get an occlusal rim. The maxillary occlusal plane was transferred to articulator using face-bow and bite registration was recorded, and articulation was done in a semi-adjustable articular (figures 8 and 9).

After teeth arrangement, the wax trial was checked in the patient mouth (figures 10 and 11). After try-in procedure processing of denture was done using an injection moulding technique. Finally, trimmed and polished cast partial was inserted in the patient mouth (figures 12). After regular recall, patient was satisfactory with the prosthesis and maintained good oral hygiene (figures 13 ,14 and 15).



Figures: 2. Pre-operative ameloblastoma 3. Post-operative resected ameloblastoma 4 & 5. Intraoral Views 6. Secondary impression (primary putty material with secondary light bodies material)7. Surveying master cast 8. Face-bow transfer 9. Articulation 10.Try-in 11. Trial wax Cast partial denture 12. Insertion view 13. Follow-up - Extra-oral view 14 & 15. Follow-up - Intra oral views

5. Discussion

Loss of mandibular continuity results in deviation of remaining mandibular segment toward the resected side primarily because of loss of tissue involved in the surgical resection.it also causes rotation of mandibular occlusal plane inferiorly on the defect side. The pull of suprahyoid muscles on the residual mandibular resected part causes inferior displacement and rotation around the fulcrum of the remaining condyle, thus giving the tendency to an open bite anteriorly [8,9]. Greater the loss of tissue more will be the deviation of the mandible to the resected side, thus compromising the prognosis of the treatment. In this case, titanium reconstructive plates create peripheral boundaries for the floor of the oral cavity and restore the form of face to a certain extent. Inadequate retention, stability, and support are common prosthodontics treatment problems for patients who underwent hemi mandibulectomy[9,10].

Cantor and Curtis classification system for mandibulectomy describes the basic principles to be strictly adhered to in designing a removable cast framework for partially edentulous patients. Usually, a quadrilateral or tripodal design is favoured over a linear design because this allows a more favourable distribution of forces for enhancing the support, stabilization, and retention of the prosthesis [11,12,13]. In dentulous patients, the number and distribution of remaining teeth determine the primary retention, support, and stability of the prosthesis [14,15]. This report described Cast partial denture prosthesis to restore the form and shape of the missing structure such as alveolar bone with teeth and gives the necessary labial support to the lower lip. The rest seat was prepared to engage the occlusal rest from which embrasure clasps arise and provide the required retention to the prosthesis [14,15].

After regular recall the patient, clinical examination showed that the patient was maintaining satisfactory oral hygiene. The patient was able to chew well and was extremely satisfied with the results.

Conclusion

A proper diagnosis and a well – designed treatment plan will result in pleasant outcomes. Rehabilitation with cast partial denture prosthesis for reconstructing the mandibular defects leads to improved function, cosmetics, and superior quality of life in appropriately selected patients. Maxillofacial prosthesis is important not only in rehabilitation and aesthetics, but also it improves patient confidence and resocialization in society.

References

1. Beumer J, CurtisT, Marunick MT. Maxillofacial Rehabilitation: Prosthodontic and surgical consideration. Ishiyaku Euro America, St. Louis, OK.1996, 184-188
2. Beumer J, Curtis T, Firtell D editors. Maxillofacial rehabilitation. St. Louis: Mosby. 1979, 90-169.
3. Schneider RL, Taylor TO. Mandibular resection guidance prosthesis: A literature review. J Prosthet Dent 1986;55:84-6.
4. Swoope CC.Prosthetic management of resected edentulous mandible. J Prosthet Dent. 1969;21 (2):197-202.
5. Cantor R, Curtis TA. Prosthetic management of edentulous mandibulectomy patients: part II, Clinical procedures. J Prosthet Dent 1971; 25:546-55.
6. Desjardi ns RP. Occlusal considerations for the partial mandibulectomy patients. J Prosthet Dent 1979; 41:308-15.
7. Kenneth FB. Complete denture treatment in patients with the resected mandible. JProsthet Dent 1969; 21:443-7.
8. Sahin N, Hekimoglu C, Aslan Y. The fabrication of cast metal guidance flange prosthesis for a patient with segmental mandibulectomy: a clinical report. J Prosthet Dent 2005; 93:217.
9. Rosenthal LE. The edentulous patient with jaw defects. D Clin N Am 1994; 8:773-779.
10. Cantor, R., Curtis, T.A., Shipp, T., Beumer, J., and Vogel, B.S. Maxillary speech prostheses for mandibular survival defects, J Prosthet Dent. 1969; 22: 253-260.
11. Cantor, R., Curtis T.A.. Prosthetic Management of Edentulous Mandibulectomy patients. Part I. Anatomic, Physiologic, and Psychologic considerations, J Prosthet Dent. 1971; 25:446-457.
12. Robinson, J.E., Rubright, W.C.: Use of a Guide Plane for Maintaining the Residual Fragment in Partial or Hemi mandibulectomy, J Prosthet Dent. 1964; 14:992-999.
13. Ashlesha Subhash Marathe, Prasad Shankar rao Kshisagar. A systematic approach in rehabilitation of hemimandibulectomy: A case report. J Indian Prosthodont Soc 2016;16:208.
14. Ferreira AN, Aras M, Chitre V, Mascarenhas K. Prosthetic Rehabilitation of a Patient with Ameloblastoma using an Unconventional Cast Partial Denture. Dentistry2018; 8:482.
15. Narendra.R, P. Seshareddy, Sashideepth Reddy, S. Arunakumari. Prosthodontic Rehabilitation of Cantor and Curtis Class III Mandibular Defect Using Cast Partial Denture: A Case Report. J Pharm Sci Res. 2016; 8(6):461-463.