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# EDITORIAL

Implementing research and publishing results is crucial for a career in sciences. Doing research is only half of the picture. Writing is the most important means for communicating scientific work. Research and publication complement teaching and training, clinical care, and public health works. There are many reasons for writing. The most compelling reason for many professionals to start writing is to fulfil specific job requirements by employers that include promotion to an academic position, professional accreditation in the form of continuing medical education (CME), and improving prospect of success in research grant application. Publications can also be regarded as an asset that enables authors to gain recognition and acknowledgement as experts in a particular field at national and international levels. Publication in peer-reviewed journals also gives international recognition for an individual, department, university, and institutions.

In the coming year expect more research work and publications from each departments of our institution. Wishing you all a Happy and prosperous New Year.

Dr. Manoj Kumar K P
Chief Editor

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# ENUCLEATION OF MULTIPLE GIANT RADICULAR CYST OF MAXILLA AND RECONSTRUCTION WITH NATIVE CORTICOCANCELLOUS BONE

*Dr. M C Chanchalesh, *Dr. Sreelatha Sadasivan, **Dr. Anroop, ***Dr. Manojkumar KP

**Abstract**

Radicular cysts are inflammatory odontogenic cysts of tooth bearing areas of the jaws. Most of these lesions involve the apex of offending tooth and appear as well-defined radiolucencies. Owing to its clinical characteristics similar to other more commonly occurring lesions in the oral cavity, differential diagnosis should include dentigerous cyst, ameloblastoma, odontogenic keratocyst, periapical cementoma and Pindborg tumour. The present case report documents a massive radicular cyst crossing the midline of the palate. Based on clinical, radiographical and histopathological findings, the present case was diagnosed as an infected radicular cyst. The clinical characteristics of this cyst could be considered as an interesting and unusual due to its giant nature. The lesion was surgically enucleated along with the extraction of the associated tooth; the defect formed is reconstructed using native cortico-cancellous bone.

**Key words:**Enucleation, Radicular cyst, Reconstruction, Cortico-cancellous bone

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## Introduction

Odontogenic cysts are a group of jaw cysts that are formed from tissues involved in odontogenesis (tooth development). They can be broadly divided into developmental and inflammatory types based on their aetiology. Inflammatory odontogenic cysts include the radicular cysts and the lateral periodontal cysts. Radicular cysts (apical periodontal cyst, dental root end cyst) are the most common inflammatory odontogenic cysts of tooth bearing areas of the jaws.[1] They originate from an epithelial rest of Malassez in periodontal ligaments secondary to inflammation.[2] They are most frequently found at the apices of the involved teeth with infected or necrotic pulps; however, they may also be found on the lateral aspects of the roots in relation to accessory root canals.[3]

Most commonly, radicular cysts occur between the third and the sixth decade of life with male predominance. Clinically, the lesion is usually small, asymptomatic but may sometimes exhibit mild pain and sensitivity to percussion. The affected tooth is usually non-vital and the surrounding mucosa may exhibit bluish discolouration.[4] Histopathologically, the radicular cyst is a chronic inflammatory lesion with a closed pathological cavity. It is lined either partially

or completely by non-keratinised stratified squamous epithelium.[2]

The present case report documents of an unusual case of an infected giant radicular cyst in the right maxilla crossing the midline of the palate. In spite of its massive size and lying close to vital structures, it did not erode the bone and integrity of important anatomical structures such as maxillary sinus, orbital floor and nasal floor were maintained. The adjacent teeth were removed during conventional surgical enucleation and reconstructed with native corticocancellous bone attached to teeth that were removed as a part of enucleation.

**Case Presentation**

A 57-year-old male patient reported to our department with a chief symptom of mild pain and swelling in relation to the right side of face and associated teeth region (Fig 1a-d). On clinical examination, there was a massive palatal swelling of size approximately 3x4 cm extending from teeth 11 to 16, crossing the midline of the palate; and a swelling of approx. 3x4 cm over buccal vestibule extending from 12 to 17. The dental history revealed repeated prescription of antibiotics and analgesics at private dental clinics for the same persistent swelling since 6 months. Medical history was unremarkable. On palpation, the lesion was soft and fluctuant. Lymph nodes were non-palpable.

**Investigations**

Radiographic examination revealed a large multilocular radiolucency with well-defined radiopaque border. CBCT (Cone Beam

**Fig 1a-d: Extraoral and intraoral views**

Computed Tomography) revealed multiple radiolucent areas over right maxilla and palate crossing the midline (Fig 2a&b). Routine laboratory investigations were within normal limits. Based on clinical and radiological analysis, a provisional diagnosis of a radicular cyst was made. After surgical enucleation and biopsy, histopathological findings confir-med clinical diagnosis of multiple radicular cyst (three in number).

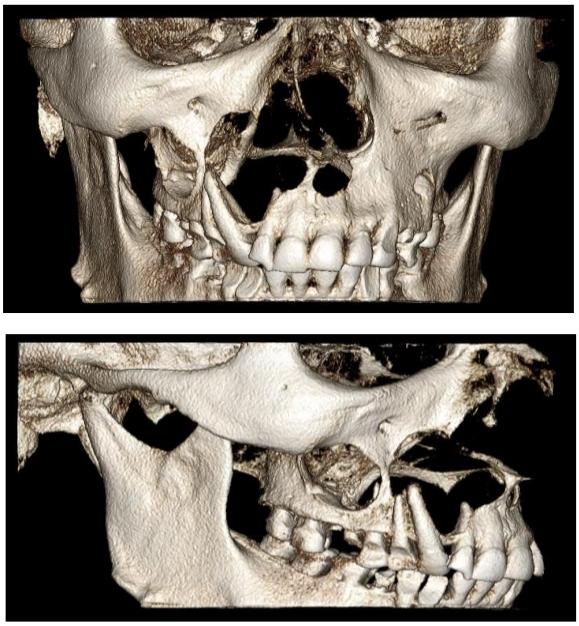


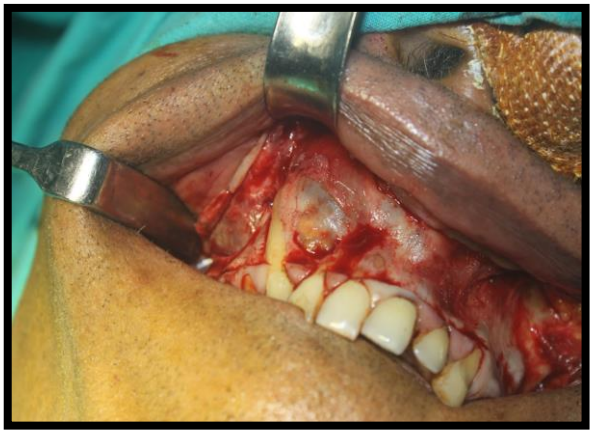
**Fig 2a&b : CBCT analysis**

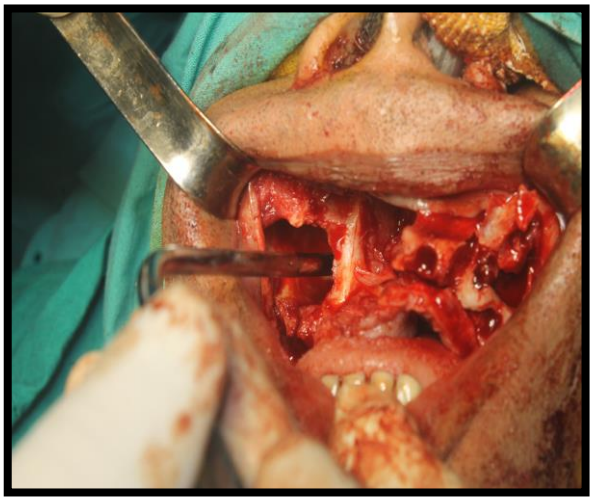
**Differential Diagnosis**

In view of its clinical characteristics, similar to some commonly occurring lesions in the oral cavity, the differential diagnosis of the radicular cysts should include dentigerous cyst, pindborg tumour, periapical cementoma, traumatic bone cyst, ameloblastoma, odontogenic keratocyst and odontogenic fibroma. Confirmatory diagnosis of the radicular cyst is established only after surgical biopsy and histopathological examination of the lesion.

**Treatment**

The patient was advised for surgical excision under and biopsy. Careful enucleation of cyst was performed along with extraction of associated teeth under General anaesthesia (Fig 3a – f).





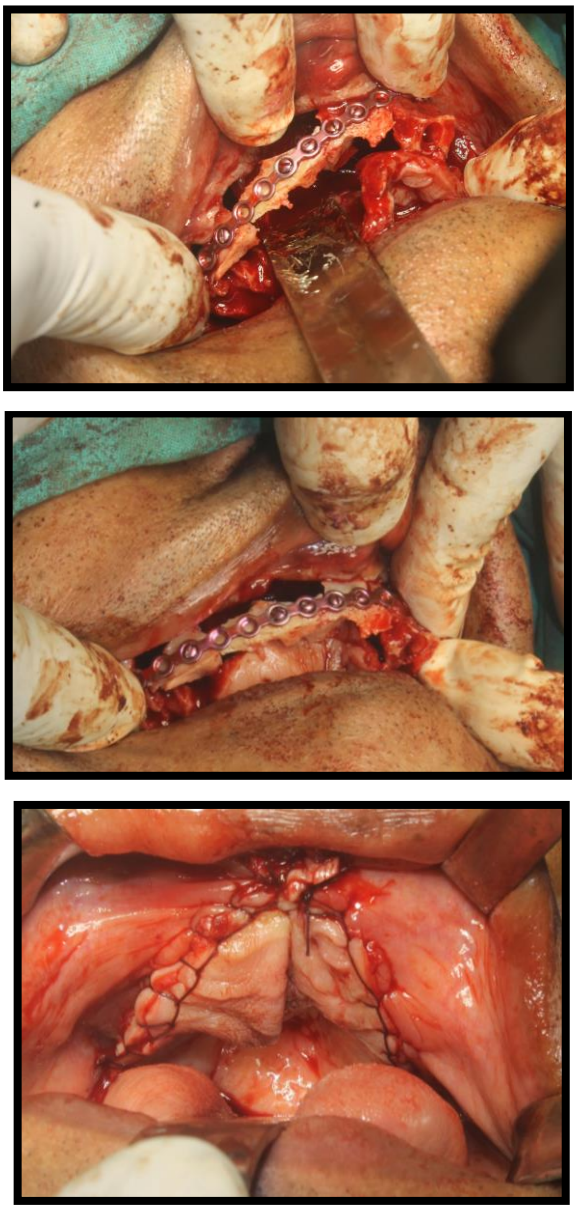


**Fig 3 a-f: Surgical procedure**

Extraction of maxillary teeth was inevitable since the lesion was extensive and involved much in alveolus. The defect formed as result of cyst enucleation is managed by reconstructing the alveolus using the native cortico-cancellous bone attached to teeth that were removed as a part of the enucleation thus avoiding the secondary site bone harvesting. The bone pieces were fixed to a reconstruction plate using screws, shaped like alveolar curvature and fixed over the two ends of the alveolus. Excised tissue was sent for histopathological investigation. Necessary prescriptions and postoperative instructions were given (Fig 4 a-d).

**Outcome and Follow-Up**

Postsurgical follow-up after 15 days showed considerable healing of surgical site. At 6 months follow-up, no recurrence was observed and orthopantamograph revealed a new bone formation at the site of cystic lesion (Fig 5a-c).

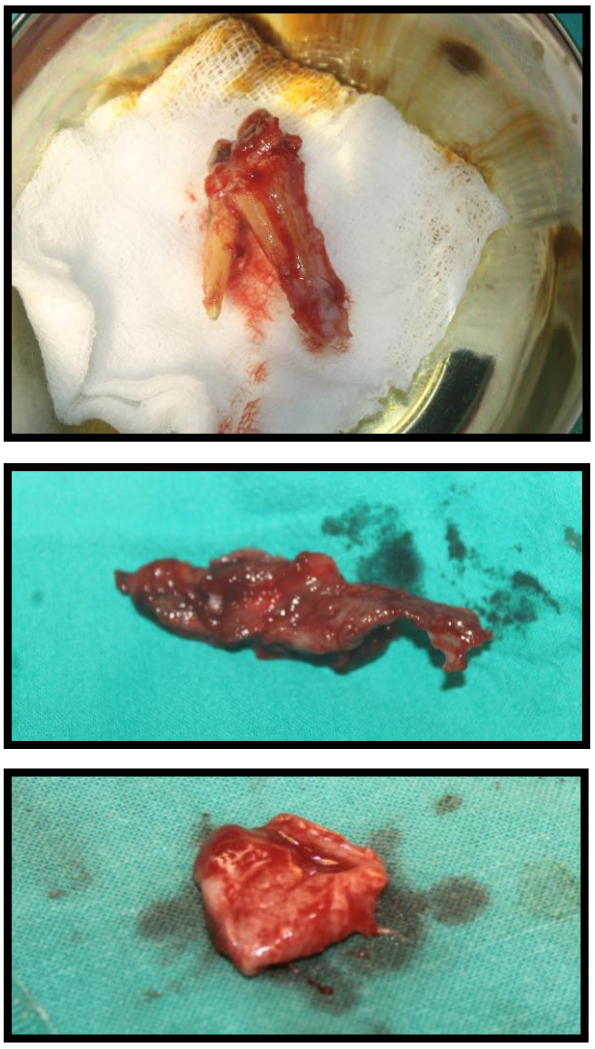


**Fig 4 a-d: Involved tooth and the cystic lining sent for biopsy**

## Discussion

Inflammatory jaw cysts comprise a group of odontogenic lesions. They originate as epithelial residues in the periodontal ligament due to apical periodontitis following the death and necrosis of the dental pulp. Radicular cysts are diagnosed either during routine radiographic examination or following their acute exacerbation. Prevalence of the radicular cysts in the maxilla is 60% as compared with mandible, and is associated with buccal or palatal enlargement.[2] The present case was associated with a huge palatal swelling with buccal involvement.

Radicular cysts grow slowly and lead to mobility, root resorption and displacement of teeth. Once infected they may lead to pain and swelling and patients become aware of the problem.[6] Radicular cystic lesions undergo asymptomatic evolution with crepitations followed by erosion and fluctuation of the overlying soft tissue. The bone in the surrounding area will be thinned out with springiness and egg shell crackling, leading to cortical plate expansion. The alveolar process exhibits a paper-like texture on palpation,[3] as seen in our case.

**Fig 5a-c: Post operative view**

Radiographically, the radicular cyst appears as round or pearshaped unilocular radiolucency at the apex of a non-vital tooth. The margin of a radicular cyst is radiopaque with hyperostotic borders, which continues with the lamina dura. However, in infected or

rapidly enlarging cysts, the radiopaque margin may not be present. The chronic radicular cyst may result in the resorption of offending tooth roots.[3] Despite being infected the present case had a clear radiopaque border and no root resorption was evident, which was helpful in the provisional diagnosis of radicular cysts. Other odontogenic cysts like dentigerous cysts, odontogenic keratocysts and odontogenic tumours such as ameloblastoma, Pindborg tumour, odontogenic fibroma and cementoma may share the same radiological features as radicular cysts. Hence histopathological evaluation is necessary most of the time to diagnose these types of giant lesions.

In extensive cases, radiographs alone may not be sufficient to show the full extent of the lesions, and advanced imaging was needed.[3,7] Hence we went for CBCT (Cone Beam Computed Tomography) imaging of the lesion. Radicular cysts are generally associated with the root apex of a carious or fractured tooth due to the presence of dead and necrotic pulp. Massive dental cysts sometimes may extend into the sinus away from the original epicentre[3] and sometimes present as a large multilocular radicular cyst.[1] The present case though massive, clinically and radiographically did not show any signs and symptoms of maxillary sinus invasion.

Simon[8] described two types of the radicular cysts. One form is a true radicular cyst which contains a closed cavity entirely lined by the epithelium and the other form of a radicular cyst is a periapical pocket cyst also known as bay cyst. The epithelium is attached at the margins of the apical foramen in such a way that the cystic lumen is open to the affected root canal. Nair[9] found that 61% were true cysts, and 39% were pocket cysts.

Histopathologically, radicular cysts are lined completely or in part by stratified squamous epithelium. These linings may be discontinuous in part and range in thickness from 1 to 50 cell layers. The lumen of a cyst contains fluid with low concentration of protein and collection of cholesterol clefts (Rushton bodies) with multinucleated giant cells. Different intensities of acute and chronic inflammatory infiltrate are present subepithelially.[10] Few cases are reported with hyaline bodies which represent a secretory product of the odontogenic epithelium in radicular cyst. The deposits of cholesterol crystals arise from the disintegration of red blood cells, lymphocytes, plasma cells and macrophages.[11] In our case, histopathological finding revealed acute and chronic inflammatory infiltrate without any Rushton bodies. Occasionally metaplastic changes, in the form of mucous cells or ciliated cells, are frequently found in the epithelial linings of radicular cysts due to migration of these cells from maxillary sinus or nasal cavity. A few well-documented cases[12,13] indicate that squamous carcinoma occasionally arises from the metaplastic changes in the epithelial lining of the radicular cysts. Long-standing cases of radicular cysts have shown histopathological evidence of transition from a cystic lining to epithelial dysplasia and further progressing as infiltrating squamous carcinomas. At present, there is no concrete evidence that cyst epithelium is at particular risk of carcinomatous transformation and no justification regarding cysts as precancerous lesions. However, clinicians should be aware

of the remote chances of radicular cyst converting into squamous carcinoma.

The recommended treatment option available for radicular cyst is the conventional endodontic approach combined with decompression[14] or surgical enucleation of a cyst with extraction of the offending tooth. Some authors are of the view that suspected radicular cysts must be totally enucleated surgically to remove all epithelial remnants.[15] The treatment of these cysts is still under discussion and many professionals opt for a conservative treatment by means of endodontic technique. However, in large lesions the endodontic treatment alone is not efficient and it should be associated with a decompression or a marsupialisation or even with enucleation.[16,17] When the lesion is small with approximately 1 cm in diameter, most clinicians opt for conventional endodontic treatment. Endodontic treatment of radicular cysts eradicates microbes or substantially reduces the microbial load from the root canal and prevents reinfection by orthograde filling.[18] Once periapical inflammation is reduced, there will be a decrease in inflammatory mediators and cytokines released by innate and adaptive immune cells and the epithelial cells of a cyst's lining epithelium will die of apoptosis.[19] Lesions that fail to resolve with such therapy may be successfully managed by extraction of the associated non-vital teeth and curettage of the epithelium in the apical zone.[18]The other options suggested are surgical decompression to reduce the size of the lesion before marsupialisation or complete enucleation is planned, to reduce the chances of damage to other teeth or anatomic structures.[20]

Conservative treatment approaches have proved to be effective for the treatment of radicular cysts in primary teeth.[18] However, surgical decompression and marsupialisation requires 3–12 weeks of prolonged follow-up and uncomfortable healing period.[21] Nair [4,9] considered that the type of cyst was important, and the true cyst is self-sustaining and may persist even after endodontic treatment. In contrast, the lumen of a pocket cyst is continuous with the root canal and thus dependent on the pulpal infection for its growth and persistence. Pocket cysts, therefore, resolve and heal after conventional endodontic treatment, and true cysts require surgical excision. As the present case represented true cyst, surgical enucleation was considered. Enucleation of large cysts in the jaws is an invasive method that may lead to complications such as damage of the adjacent teeth or anatomic structures, but contemporaneous and less invasive surgical techniques for treating large radicular cysts have been developed.[21] Endoscopically assisted enucleation is an innovative alternative method that can be as conservative as marsupialisation, allowing preservation of important surrounding structures, with the greater advantage of one step treatment, reduced healing period and very low morbidity. The endoscopic approach provides good visualisation of the whole cystic cavity allowing the removal of any pathological tissue and preservation of integrity of the vital anatomical structures involved.[21] The current case was of a giant infected true cyst, and the patient had

consulted many dentists for the persistent problem. Thus, one step conventional surgical enucleation and extraction of offended tooth was performed, as this technique is more used in treating massive lesions.[22]

## Conclusion

Reconstruction using particulate bone or corticocancellous bone blocks in combination with reconstruction plates or implants installed into the residual maxilla has previously been studied and reported. We reconstructed the alveolus using the native corticocancellous bone attached to titanium recon plates to re establish the facial contour, hence avoiding secondary site bone harvesting. With proper healing and post operative care the defect site can be hence rendered stable and aesthetically satisfactory.

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# CENTION N: A REVIEW

*Dr. Deepa Jayaraj, **Dr. Elsy P Simon, ***Dr. M Ramesh Kumar, ****Dr. Ravi S V

**Abstract**

Cention N is a resin based esthetic direct restorative material manufactured by Ivoclar Vivadent (Schaan, Liechtenstein). It contains an alkaline glass filler which releases hydroxide, calcium and fluoride ions and hence it is named as "Alkasite". The hydroxide ions regulate $p^H$ during acid attacks and thus prevent demineralization. The release of large number of fluoride and calcium ions form the basis of remineralization. It is being proposed for bulk placement without adhesive in retentive preparations and with adhesive in non-retentive preparations. It can be used as pediatric restorative material and class I,II and V restoration in permanent dentition.

**Key words:** Cention N, alkasite, restorative material

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## Introduction

Dental amalgam, one of the most versatile restorative material has been efficaciously used by dental clinicians as a low cost strong direct restoration for the last two centuries compared to other relatively new materials.[1] However, with the ongoing concerns about environment and health implications of mercury, it is showing decline in its use globally.[2-5]

Dental amalgam represents the most common form of human exposure to mercury and along with its use in lab and medical devices comprises to 53% of total global mercury emission (WHO 2005).[6] Around 340 tons of mercury is used per year in dentistry, of which about 70-100 tons (20-30%) enters the solid waste stream (UNEP 2013).[7] In recent years, development and interest in esthetic dentistry has increased and there is a considerable demand for alternative filling materials.[8]

Cention N is a new resin based direct restorative material introduced by Ivoclar Vivadent; Schaan, Liechtenstein in 2016. It is tooth-colored esthetics material with high flexural strength. It belongs to the alkasite group, a sub group of composites like compomer or ormocer. This new category includes an alkaline filler, capable of releasing acid-neutralizing ions. It is named alkasite as it contains an alkaline filler in its composition. The word Cention came from the Latin word "*centum"* meaning hundred and "cention" means hundred ions.[9]

## Composition

### Liquid

The organic monomer part of Cention N is found in liquid. It consists of four different methacrylates namely UDMA, DCP, an aromatic aliphatic UDMA and PEG-400 DMA which represent 21.6wt % of final mixed material. It does not contain Bis-GMA, HEMA or TEGDMA. Dimethacrylates have two polymerizable methacrylate groups. In addition to dimethacrylates, liquid contains initiators, catalysts and other additives.

**Table1: Composition of liquid**

| Composition | Weight % | Function |
|---|---|---|
| UDMA (Urethane dimethacrylate)<br>DCP (Tricyclodecan-dimethanol dimethacrylate)<br>Aromatic aliphatic-UDMA (Tetramethyl-xylylendiurethane dimethacrylate)<br>PEG-400 DMA (Polyethylene glycol 400 dimethacrylate) | 95-97 | Monomer |
| Additives | 1-2 | |
| Initiator (hydroperoxide – self cure) | 2-3 | |
| Stabilizer | <1 | |

UDMA is the main component of the monomer matrix. It is hydrophobic, exhibit low water sorption and strong mechanical properties. DCP has low viscosity and is difunctional and makes it hand mixing one. Its cyclic aliphatic structure also provides strong mechanical properties. Aromatic aliphatic UDMA is hydrophobic and highly viscous. PEG-400 DMA enhance the flowability of Cention N. Its hydrophilic character also promotes Cention N's ability to wet tooth substrate (enamel and dentin) and adapt to the smear layer.

### Powder

The filler composition is found in cention N powder. The inorganic fillers include barium aluminium silicate glass filler, ytterbium trifluoride, an isofiller, calcium barium aluminium fluorosilicate glass filler and an alkaline calcium flouro silicate glass filler with particle size between 0.1- 35 micrometer. All the fillers except ytterbium trifluoride are surface modified to ensure wettability by the liquid incorporation into polymer matrix.

**Table 2: Composition of powder**

| Composition | Weight % | Function | |
|---|---|---|---|
| Calcium fluorosilicate glass | 25 - 35 | Ion release F-, Ca 2+,OH- | Filler |
| Ba-Al silicate glass | 20 - 30 | Strength | |
| Ca-Ba-Al fluorosilicate glass | 10 - 20 | Strength Fluoride release | |
| Ytterbium trifluoride | 5 – 10 | Radiopacity | |
| Isofiller (Copolymer) | 15 - 25 | Shrinkage stress reliever | |
| Initiator (a copper salt & thiocarbamide- self cure) (Ivocerin and acyl phosphine oxide-photo initiator) | < 1 | Initiator | |
| Pigment | < 0.1 | Pigment | |

**Mode of supply**

Cention N is available in powder liquid form. It is a basic, tooth colored resin-based restorative material for direct restorations. It is self-curing with optional additional light-curing. Cention N is available in the tooth shade A2.

**Manipulation**

Cention N provided as powder and liquid like glass ionomer cement that can be mixed by hand directly before use on paper pad with plastic spatula. One scoop of powder is used per 1 drop of liquid, corresponding to a powder/liquid weight ratio of 4.6 to 1.

Due to the sole use of cross-linking methacrylate monomers in combination with a stable, efficient self-cure initiator, Cention N exhibits a high polymer network density and degree of polymerization over the complete depth of the restoration. This is a good basis for long lasting restorations.

**Setting reaction**

Setting can be done by two mechanisms.

**1. Self-cure mechanism**

When cention N is used in the self-cure mode, the mixed restorative is applied in the cavity, condensed and sculpted and then left to set for 4 minutes. Self-curing systems are always made up of two components, which are kept separate to prevent any premature reaction. The self-curing process is based on an initiator system consisting of a copper salt, a peroxide and a thiocarbamide. The liquid part of Cention N contains the hydroperoxide and the standard filler in the powder part of the product is coated with the other initiator components. The copper salt accelerates the curing reaction by redox catalysis. Copper ions undergo oxidation with hydroperoxide and reduction with thiocarbamide.

As the initiator system is separated, self-cure-polymerization can only take place when the liquid and powder are mixed together. This self-cure mechanism, involving radical formation and redox catalysis with Cu-ions is illustrated below.

This initiator system has certain advantages over conventional self-cure initiator systems such as benzoyl peroxide/amine systems. The incorporation of a hydroperoxide that is more stable than benzoyl peroxide (BPO) imparts the material with greater temperature-resistance. The use of thiocarbamide rather than amine also improves the color stability of the product. It is generally accepted that the color stability of a material decreases with increasing amine content.

**2. Light-cure (dual-cure) mechanism**

After mixing, the self-curing processes will initiate. However, for speed and convenience in finishing the restoration, it may be advantageous to utilize the optional light cure function. Cention N contains the photo initiator Ivocerin® and an acyl phosphine oxide initiator for optional light-curing with a dental polymerization unit. Ivocerin, is a dibenzoyl germanium derivative 27,28. It is an amine free, Norrish Type I initiator. Norrish Type I initiator requires just one component for radical formation. A Norrish Type II initiator such as camphoroquinone requires two components for light-induced radical formation to take place. Ivocerin

exhibits a yellow color. Ivocerin however can be used in relatively small quantities due to its high absorption coefficient/enhanced reactivity, thus its properties can be utilized without negatively affecting the optical properties of the restorative. Any yellow color largely disappears during curing.

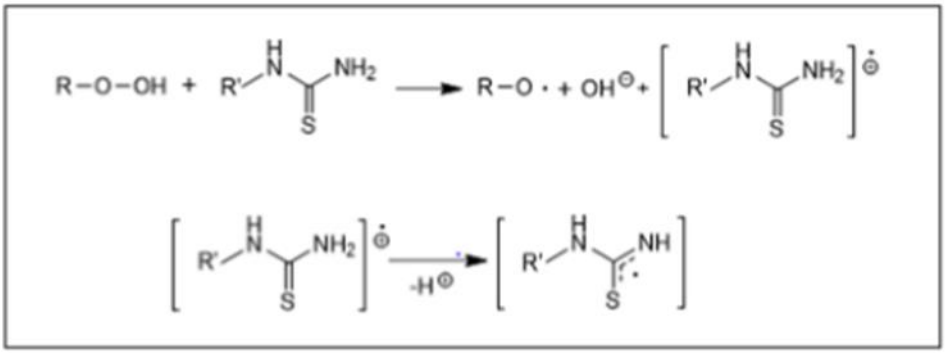


**Fig 1: Self cure mechanism of Cention N :Radical formation**

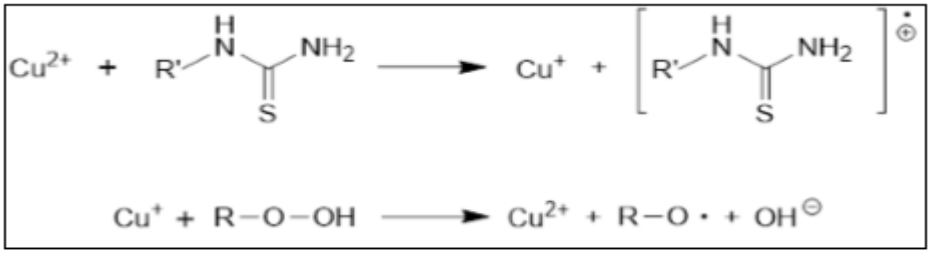


**Fig 2: Mechanism of redox catalysis with Cu-ions**

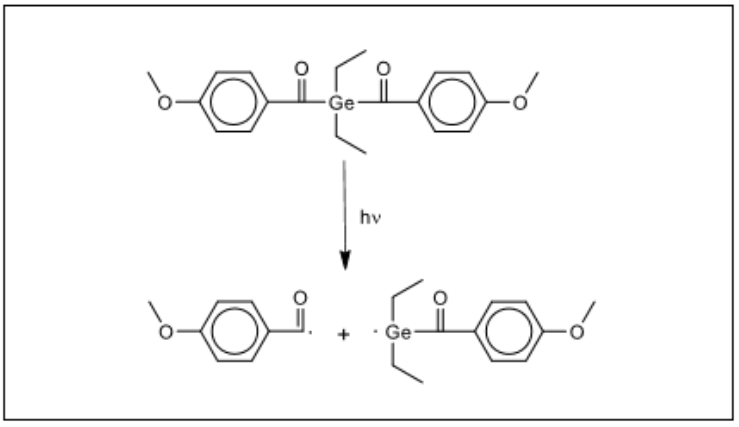



**Fig 3: Light cure mechanism of Cention N with Ivocerin**

Polymerization takes place via free radical polymerization. Incoming photons from the curing light are absorbed by the initiator Ivocerin, leading to cleavage of a chemical bond within the initiator molecule and two radicals are formed, which subsequently react

with the monomer to produce a polymer network.

In general, the darker and/or more opaque a material is, the shallower the depth of cure because less light can reach the initiators within the material, however as Cention N is a dual cure material featuring self-curing and light-curing initiators, it can be applied as a full volume replacement material i.e. in bulk. The light cure mechanism of the Norrish Type I initiator, Ivocerin is depicted in the diagram below.

When light-cured, the light is only able to penetrate layers of up to 4mm in thickness, therefore in cavities deeper than 4mm, the (self-cure) setting time of 4 minutes must be observed.

Mixing time: 45-60 seconds

Working time: 2.5 minutes

Overall setting time: 4 minutes

**Properties**

- ***Ion release***

After mixing, Cention N contains 78.4% wt. inorganic filler. The alkaline glass accounts for 24.6% in weight of the final material and these release fluoride (F-) ions - comparable to those released by traditional glass ionomers. The alkaline glass also releases hydroxide and calcium (OH- and Ca2+) ions which can further help in preventing demineralization of the tooth substrate. The release of ions depends on the pH value in the oral cavity. When the pH is low (acidic), Cention N releases a significantly larger amount of ions than when the pH is neutral.

- ***Fluorapatite/Calcium fluoride***

The inhibition of demineralization/caries formation, by reducing solubility of enamel due to the formation of fluoroapatite by the incorporation of fluoride ions into enamel. Anti-caries activity of fluoride also by the formation of a calcium fluoride layer over the teeth that acts as a reservoir of ions. Fluoride is also possessing antibacterial properties – it reduces the cariogenic (lactic) acid formation in plaque bacteria, such as Streptococcus mutans, by impairing bacterial glucose uptake and glycolysis.

- ***Hydroxide Ions***

The alkaline glass of Cention N releases hydroxide ions, that can neutralize acidic condition created by cariogenic bacterial activity.

- ***Shrinkage stress reliever***

Cention N is a full volume replacement material, designed to be applied quickly and conveniently in bulk. In this context, it is important that the material exhibit low polymerization shrinkage and low shrinkage force. Problems associated with polymerization shrinkage such as marginal discoloration, marginal gaps, cracking and hypersensitivity can be minimize.

Cention N includes a special patented Isofiller (partially functionalized by silanes) which keeps shrinkage stress to a minimum. This Isofiller, which is also used in Tetric N-Ceram Bulk Fill, acts as a shrinkage stress reliever which minimizes shrinkage force, whereas the organic/inorganic ratio as well as the monomer composition of the material, is responsible for the low volumetric shrinkage.

When the material polymerises, either in self-cure mode or via additional light-curing, the monomer chains located on the fillers together with the silanes begin a cross-linking process and forces between the individual fillers come into play which (if the restorative has been placed adhesively) place stress on the cavity walls. This stress is influenced by both volumetric shrinkage and the modulus of elasticity of the material. A high modulus of elasticity denotes inelasticity and a low modulus of elasticity denotes higher elasticity. Due to its low elastic modulus (10 GPa) the shrinkage stress reliever within Cention N acts like a spring (expanding slightly as the forces between the fillers grow during polymerization) amongst the standard glass fillers which have a higher elastic modulus of 71 GPa.

The silanes bonded to the filler particles improve the bond between the inorganic filler (glass and quartz particles) and the monomer matrix as they are able to establish a chemical bond between the glass surface and the matrix. Ultimately, the volumetric shrinkage and shrinkage stress in Cention N are reduced during polymerization – allowing bulk increments to be placed.

- ***Radiopacity***

The ytterbium fluoride filler also provides radiopacity (280% Al).

- ***Translucency***

Cention N is a relatively translucent material (transparency 11%) compared to other glass ionomer-based products.

- ***Flexural strength***

Flexural strength is a measurement of materials ability to bend before it breaks. Self-cured Cention N has flexural strength of 110MPa.

- ***Compressive strength***

Compressive strength is the ability of a material to resist compression. 300MPa is the compressive strength of self-cured Cention N.

- ***Modulus of elasticity***

This gives the relative stiffness of the material. Materials with higher the modulus are more rigid. For Cention N, it is 13GPa.

**Clinical application**

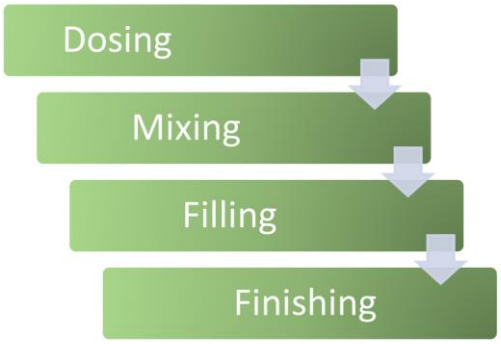
1. For restoring deciduous teeth and
2. For permanent restorations of a Class I, II or V.

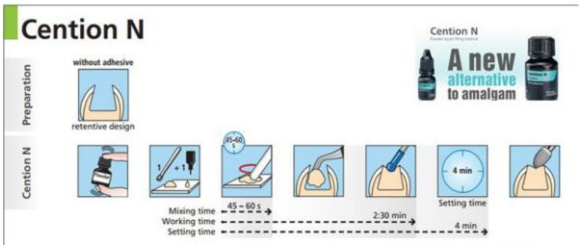
Cention N can be used with or without an adhesive. If used without adhesive, then retentive preparation (with undercuts) similar to that used with amalgam fillings is required without enamel margin beveling and etching with phosphoric acid. If it is used with an adhesive, then the cavity is prepared according to the modern principles of minimally invasive dentistry i.e. by preserving as much natural tooth structure as possible and require phosphoric acid etching.

As a dual-cured material it can be used as a bulk replacement material. Optional light curing can be carried out with blue light in the wavelength range of approximately 400 – 500 nm. Therefore, all standard polymeri-zation lights can be used to cure the material.

**Clinical steps**

Four working steps of application:




**Studies on Cention N**

Samanta et al (2017) conducted a study on microleakage in class V cavity filled with flowable composite resin, glass ionomer cement and cention N and concluded that all materials showed some microleakage at the cervical margin of restoration however Cention N exhibited lowest microleakage.[10]

Deepak et al (2017) conducted a study to evaluate proximal contact tightness between two different restorative materials using dental floss under foreign direct investment criteria. He concluded that there was no statistically significant difference between Cention N and Charisma composite. Cention N can be used as an alternative in restoring Class II restoration.[11]

Mazumdar et al (2017) conducted a study to evaluate the hardness of four restorative materials, nanohybrid composite resin, Cention N, silver amalgam and type II GIC Materials. He concluded that the microhardness of restorative materials could withstand the masticatory forces in the clinical context. Cention N showed better microhardness properties becoming a more clinically suitable option for minimal invasive treatments.[12]

Biswas et al (2018) conducted an in vitro study to evaluate the fracture resistance of mandibular first molars with class I occlusal preparations, restored with light cured composite Dyract XP, silver amalgam and Cention N in comparison with intact and unrestored teeth. He concluded that teeth restored with Cention N showed highest fracture resistance value compared to Dyract Xp light cure Composite and Silver Amalgam restoration.[13]

**Conclusion**

Despite of the long history and popularity of dental amalgam restorations, its use has been declining in practice due to the esthetic concerns of patient, mercury waste management. With increase in demand for esthetic restoration in posterior region lead to the development of various tooth colored restorations. None of them succeeded in competing with dental amalgam yet. Cention N a resin-based material is easy to handle clinically and not require any special products or additional skills. As there is demand in tooth colored posterior restoration with sufficient strength, this material will be a cost-effective way to deliver a high quality predictable restoration in less time.

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# EMERGING TECHNOLOGY TRENDS IN PROSTHODONTICS

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**ABSTRACT**

Prosthodontics is a well-defined and broad dental specialty delivering a wide range of oral rehabilitative treatment requirements. It deals mainly through prosthetic replacement. With the rapid improvement in oral health and the reduction of edentulism, more number of people are retaining teeth in the later stages of their lives. Gradually, the main focus in prosthodontics has shifted from removable dentures to fixed prostheses, while implant-supported restorations have attracted intense interest in the dental community. Another factor increasingly influencing prosthodontic practice is patient's awareness of newer technologies in esthetic dentistry as well as the other aspects of prosthetic rehabilitation. This review attempts to provide a glimpse into the current techniques in the discipline of Prosthodontics.

**Key words:** emerging trends, prosthodontics, patient management

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## Introduction

The goal of prosthodontic care has been defined as the improvement of oral function and the resolution of esthetic problems. The goal of prosthodontic care that we seek today is to enrich the quality of life of each patient by solving problems caused by disturbances of occlusion, chewing, swallowing, and appearance. To ensure these goals, the value of prosthodontics is to be enhanced by dispensing evidence-based clinical care, evolving creative prosthodontics, strategic planning etc. The future prospects of our discipline can be examined and understood only in the context of current trends and prospects.[1] The purpose of this review is to illustrate the enormous advancements that has taken place in various techniques in the field of prosthodontics in the last few years.

## Technology and Prosthodontics

Modern technologies applied to the field of prosthodontics are:(1) CAD/CAM,(2) Clinical microscopy and magnification,(3) Robotics: (Patient care, laboratory),(4) Imaging:(a) Radiography-(i) In office volumetric radiography,(ii) Interactive computer softwares etc; (b) Clinical Dentistry - (i) Intraoral impressions, (ii) Cast duplication, (iii) Restoration fabrication, (iv) Custom dental implants, abutments, and restorations, (v) Guided implant surgery, (5) Occlusion: Analysis. Eg. Tekscan, Cardiax compact, (6) Electronic shade matching, (7) Lasers-soft and hard tissue, (8) Nano technology, (9) Genetics, (10) Information management systems, (11) Rapid proto typing, (12) Virtual articulators, (13) CBCT, (14) Swept-Source Optical Coherence

tomography (SS-OCT), (15) Laser-induced Fluorescence, (16) Laser Photothermal Radiometry (PTR), (17) Ultrasonography, (18) Infrared spectroscopy for multiple inflammatory parameters, (19) 3D Printing techniques, (20) Optical scanning of teeth (Digital impressions), (21) Direct Metal Laser Sintering (DMLS), (22) Tissue Engineering, and (23) Computer-aided Educational Systems: (a) Haptic Technology, (b) Just-in-time Learning.[2] Some of the Modern technologies applied to the field of prosthodontics include :

**(1) CAD/CAM**

Fabrication of final dental restorations through conventional practices involves a complicated process. A comparatively new approach employs Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology such as to take a digital impression intra orally, fabricate the master model, and design as well as produce the final restoration. There are certain advantages of digital impressions in implant and fixed prosthodontics as we compare with the conventional impression techniques which include lessened time interval between clinic and dental laboratory, less discomfort to the patient and elimination of laboratory steps that may lead to more fit issues.[3]The digital impression concept has become a trend and spreading quickly on the horizon and it is accepted that digital impressions will solve the limitations and difficulties of the conventional impressions. Dr. Duret first introduced the CAD/CAM concept to dentistry in 1973 in Lyon, France in his thesis entitled Empreinte Optique, which translates to Optical Impression.[4] The concept of CAD/CAM systems was further developed by Dr. Mormann, a Swiss Dentist, and Mr. Brandestini, who was an electrical engineer. CEREC was the first commercially available digital impression system for use in the field of dentistry. Over the last 10 years, systems like 3M Lava C.O.S., CadentiTero, E4D Dentist, and 3Shape Trios have been introduced. Till date, various CAD/CAM systems are now available for dental applications. Each employs a specific, distinct technique for making impressions.[5]

**(2) Clinical microscopy and magnification**

The microsurgical tools can also be used in tooth preparation and final restoration of the tooth in fixed prosthodontics. In this regard some interesting observations are made by Leiknius and Geissberger. The study carried out by them shows positive results. The dental students using devices like low-magnification telescopic loupes made very less errors in preparation design and laboratory processing. The errors by these students were reduced to half while compared with another set of control group students who were not using magnification devices. The study also showed that the microscopes are extremely useful during the try-in and seating appointments.[6]

The magnification devices proved to be beneficial even to laboratory technicians who could trim the stone dies with utmost precision and improve the quality of prosthesis with the aid of microscopes.

**(3) Robotics**

Application of robot to prosthodontics is a novel application of robot technology in medical field. Robot not only increase the

productivity of the workers, taking the place of human to do the repeated, boring, and dangerous work, but also accomplish some work where human is not competent.[7] Therefore, robot is paid much attention and widely used increasingly.

*Applications*

1. Tooth-Arrangement Robot - Aiming at the problem of traditional manufacturing methods of complete dentures, a concept of professional and miniaturized Cartesian type robot for tooth-arrangement is put forward based on TRIZ theory.[8] The three-dimensional structure of Cartesian type tooth-arrangement robot is designed.

2. Dental Implantology Robot -A computer assisted preoperative planning and surgical navigation system in dental implantology is constructed.[9] Patient-specific 3D models are reconstructed from preoperative Cone-beam CT images, and implantation planning is performed with these virtual models. A two-step registration procedure is applied to transform the preoperative plan of the implant insertion into intraoperative operations of the robot with the help of a Coordinate Measurement Machine (CMM). A CMM is introduced into our system acting as the reference coordinate system, to avoid direct contact between the robot and the patient during the setup stage, thus ensuring the safety of the patient.

**(4) Imaging:- a) Radiography - (i) Cone beam computed tomography (CBCT)**

*Pre-implant imaging*

The clinician placing dental implants needs to determine the best possible sites with respect to restorative, esthetic, biomechanical and functional requirements. CT images will allow the clinician to assess the following: bone height and width dimensions, bone quality, long axis of alveolar bone, internal anatomic considerations, external jaw boundaries and presence of pathology. Any point in space in the CT scan can be reference from a known intra-oral anatomic landmark (eg: tooth, mental foramen, nasopalatine canal) to allow for the transfer of radiographic information to the clinical site. For clinical/radiographic referencing, some clinicians prefer the use of imaging stents with radiopaque markers. Because of image artifact from metals, gutta percha is the marker of choice with cone beam CT.

*TMJ*

Imaging of the temporo-mandibular joint continues to be an area of interest to the dentist and often imaging of the joints is requested to support clinical findings and/or rule out pathology. With cone beam CT, we can visualize the condyle and fossa in multiple planes of section from a single scan and assess anatomical changes not previously seen on plain films.

**(5) Occlusion: Analysis. Eg. Tekscan, Cardiax compact**

The "T-Scan I" was invented 25 years ago, and since then, the entire system has undergone hardware, sensor, and software revisions, such that today's "T-Scan III"

system (version 7.0) is vastly improved over the earliest "T-Scan I" system. T-Scan III analyzes the order of the occlusal contacts while simultaneously measuring the force percentage changes of those same contacts, from the moment the teeth first begin making occlusal contact, all the way through to maximum intercuspation. Therefore, it can assess the initial occlusal contact, the order that all the occlusal contacts occur in, and the amount of relative occlusal force loading each contact. It enables us to assess the force changes, all during the process of contact evolution. T-Scan III quantifies the amount of relative occlusal force, which enables us to predictably identify and locate traumatic occlusal contacts.

**(6) Electronic shade matching**

Spectrophotometers, colorimeters and imaging systems are useful and relevant tools for tooth color measurement and analysis, and for quality control of color reproduction. Different measurement devices either measure the complete tooth surface providing a "color map" or an "average" color of the limited area [3-5mm] on the tooth surface. These instruments are useful tools in color analysis for direct or indirect restorations, communication for indirect restorations, reproduction and verification of shade. Whenever possible, both instrumental and visual color matching method should be used, as they complement each other and can lead towards predictable esthetic outcome.[10]

**(7) Rapid prototyping**

Dentists have used rapid prototyping (RP) techniques in the fields of oral maxillofacial surgery simulation and implantology. With new research emerging for molding materials and the forming process of RP techniques, this method is becoming more attractive in dental prosthesis fabrication. The application of RP techniques for prosthodontics include: (1) fabrication of wax pattern for the dental prosthesis, (2) dental (facial) prosthesis mold (shell) fabrication, (3) dental metal prosthesis fabrication, and (4) zirconia prosthesis fabrication.[11]. Many people could benefit from this new technology through various forms of dental prosthesis production. Traditional prosthodontic practices could also be changed by RP techniques in the near future.

**(8) Virtual articulators**

Using a virtual procedure, the maxillary digital cast is transferred to a virtual articulator using reverse engineering devices. The following devices necessary to carry out this protocol are an intraoral scanner, a digital camera, and a specific software. Results prove the viability of integrating different tools and software and of completely integrating this procedure into a dental digital work flow.[12] The virtual articulator is one such application in prosthetic restorative dentistry based on virtual reality that will significantly reduce the limitation of the mechanical articulator and by simulation of real patient data, allows analysis of digitized casts with regard to static and dynamic occlusion as well as jaw relation.[8] Virtual interocclusal records are used to orient the maxillary and mandibular casts in horizontal jaw relation.

**(9) Optical scanning of teeth (Digital impressions**

Under the term 'scanner' one understands, in the area of dentistry, data collection tools that measure three dimensional jaw and tooth structures and transform them into digital data sets. Basically there are two different scanning possibilities:

• Optical scanners
• Mechanical scanners

a) Optical scanners -The basis of this type of scanner is the collection of three-dimensional structures in a so-called 'triangulation procedure'. Here, the source of light (eg. laser) and the receptor unit are in a definite angle in their relationship to one another. Through this angle the computer can calculate a three-dimensional data set from the image on the receptor unit.Either white light projections or a laser beam can serve as a source of illumination (Fig. 1). The following can be named as examples of optical scanners on the dental market:
   • Lava Scan ST (3M ESPE, white light projections)
b) Mechanical scanner - In this scanner variant, the master cast is read mechanically line-by-line by means of a ruby ball and the three-dimensional structure measured. The Procera Scanner from Nobel Biocare (Göteborg) is the only example for mechanical scanners in dentistry. This type of scanner is distinguished by a high scanning accuracy, whereby the diameter of the ruby ball is set to the smallest grinder in the milling system, with the result that all data collected by the system can also be milled 5, 10 The drawbacks of this data measurement technique are to be seen in the inordinately complicated mechanics, which make the apparatus very expensive with long processing times compared to optical systems

**Conclusion**

The changes in the discipline of prosthodontics over the last few decades, largely as a result of developments of new materials and methods, but also of prevention and improved dental health, have been momentous. Such developments and probably some new initiatives as well, will most certainly continue to occur. The revolution of dental implants, as well as other newer technologies of which high-strength ceramic and CAD/CAM technologies are notable examples, are in various stages of establishing themselves as part of 'mainstream' prosthodontics. While such developments have led to substantial changes in clinical prosthodontics, education in many respects seems to lag behind. Nevertheless, a concentration on advancing high technology in prosthodontics and related areas is likely to continue.

With the advent of digital technology and various other advancements in technology in prosthodontics, it is interesting to note how technology can be integrated toward planning and treatment and hopefully they become affordable to the dentists so that the process of treatments become less time-consuming and more efficient.

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# WHATSAPP IN DENTISTRY: WHERE THERAPY MEETS TECHNOLOGY

*Dr. Nimisha M, *Dr. Prejith Sampath, **Dr. Hamesh Gangadharan

**Abstract**

Increased use of smartphone and related software applications has created a new erain clinical data exchange among patients and clinicians. The result of which is the teledentistry, an innovative field that involves the exchange of clinical information and images over remote distances for consultation and treatment planning by linking them with the specialists in larger communities. WhatsApp Messenger is cross-platform mobile messaging application that demonstrated its utility and efficacy in various clinical setting WhatsApp has a facility to create groups for discussions. It has also got the facility of videoconferencing. People with disabilities and inability to visit the dentist have also benefited after it was introduced. Social medias like WhatsApp is able to develop interesting learning environments. This review briefly discusses the applications of WhatsApp in dentistry along with its demerits.

**Keywords:** WhatsApp; Dentistry; Dental tourism

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## Introduction

Smartphones have become so ubiquitous that the number of people who don't own a smart phone are few. Smartphones besides serving their original purpose, have replaced a range of devices from alarm clocks to cameras. They can be used for internet browsing, to access email and social media applications, to identify oneself globally using GPS and for taking good quality pictures that are comparable to professional cameras. A number of third party applications can also be accessed through the store, some of which can enable a professionalism to one's work.

Social networking platforms are internet-based applications in which user-generated content is created and exchanged by a large number of people. The ease with which students can access social media through mobile devices and the increasing amount of time they spend doing so can be utilised for educational purposes.

Messaging is the way users communicate instantly via their mobile devices and it has become one of the most popular methods of communication. Of particular mention is the WhatsApp Messenger, which has more than a billion users worldwide. WhatsApp was designed to replace short message service with an Internet-based platform thus allowing users to avoid the international fee.

In 1997, Cook coined the term "Teledentistry" and defined it as the practice of using video-conferencing technologies to diagnose and provide treatment advice over a distance with a goal to improve the patient's clinical health status and outcome. A growing variety of applications and services like video conferencing, email, wireless tools, and other forms of telecommunication technology are included in teledentistry.[1]

The reduced cost of owning a smart phone along with decreased data charges has helped to revolutionise teledentistry by making it accessible to all. WhatsApp is one of the most popular messaging applications because it has one of the largest user bases along with a simple user interface. Recent inclusion of video conferencing and the ability to attach large documents has made it an attractive option for telemedicine.[2]

In 1987 Chickering and Gamson proposed seven principles which include good teaching and learning in colleges, including high expectations, communication between students and faculty, reciprocity and cooperation among students, active learning and prompt feedback. Also time on task and respect to talents and ways of learning diversity should be emphasized. WhatsApp and other instant messaging applications meet these criteria for best practice in education and have a beneficial effect on learning.[2]

**Applications of WhatsApp in Dentistry**

Even before the advent of Whatsapp, teledentistry existed in a very crude form where images and documents regarding patients were shared through email. This had a few disadvantages as an average person would access her mail about once a day. This delay has been offset by social applications like WhatsApp. WhatsApp can be used for,

- Acquiring & editing the image - It can be done directly through the WhatsApp camera. Here areas of interest can be cropped & digitally enhanced before highlighting points of interest to attract the attention of the viewer. For example, the contrast of a radiolucent area can be enhanced to standout in the image. This can further be highlighted using markers of different colours.
- Group discussions – WhatsApp has a facility to create groups for discussions. Using this facility, intra department and inter department discussions can be held. This can be in the form of text chats, voice messages or videos if record of details needs to be maintained or in the form of video-conferencing for live discussions. Intra department discussions help in getting a consolidated diagnosis with input from all the members within the department. This can then be sent to another group which includes the representatives of various departments. By following step wise approach, maximum advantage can be reaped out of this.
- Tertiary centre referrals – If treatment cannot be provided at the primary centre, the patient will need to be sent along with a referral letter to the tertiary centre. Patient photos, a copy of the referral letter along with a short communication can be

sent through WhatsApp to help the specialist to be better prepared to treat the patient. It also saves time for both the patient and the specialist. Similarly, post-surgical documentation and photographs can be sent back to the referring doctor without troubling the patient.

- Specialist tele-dentistry – In remote areas in developing & underdeveloped countries, without access to specialist care, video-conferencing can help bring the specialist virtually to the location for advice. This can help in improving patient care besides bringing down the cost and time which would have resulted from an actual visit by the specialist.
- Treatment follow up - India being a developing country has a large number of expatriates working in foreign countries. Most of them seek treatment when they visit their homeland during their annual vacation. However most of them will need to leave without proper follow up which can be a major cause for treatment failure. This can be offset by interacting with patient directly or with his dentist in the host country.
- Dental tourism - Recently there has been a trend for people from developed countries to visit English speaking developing countries for treatment. This is due to the exorbitant cost involved in their home country. Dentist can get together with tourist agencies to create packages that can be promoted through social media apps like WhatsApp.

**Advantages**

- Save time
- Saving money
- Easy to use
- Saving appointment
- Team discussion
- Speciality group discussions
- Patient education & motivation
- Safe because of end to end encryption
- Follow-up for patients living abroad
- Eco friendly – paper less
- Compare performance with that of their peers in the groups
- Increased interaction with clinicians regionally, nationally, and globally
- Exchange and availability of relevant information and knowledge
- Distribution and discussion of information and cases for education and research
- More active engagement during scientific meetings
- Augmentation of the reach of scientific publications by promotion on social media

**Disadvantages**

- Direct interaction is always the best method of patient examination
- Hoax messages, some with seemingly sound scientific support that can even fool educated people
- Risk of inappropriate and unprofessional online behaviour
- Reduced clarity of images
- An internet connected mobile phone is necessary

- Images shared between the intended group can be further shared leading to a breach of confidentiality
- Can lead to copyright infringement

## Conclusion

WhatsApp has made life easier on several fronts for both the patient and the physician. It not only saves time but is also lighter on the pocket. People with disabilities and inability to visit the dentist have also benefited after it was introduced. However, it must be remembered that it is the patient and not the documentation or photographs that need to be treated. It is therefore important that the patients visit at least once or as required by the dentist so that they receive optimal care.

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# BOND WITH THE BEST

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**Abstract**

Hybridization of the dentin with resin by monomer interdiffusion has been identified as the basic bonding mechanism resulting in an intimate interlocking of the cured resin with the dentin. Today, growing efforts are made to simplify and shorten the bonding procedures. Rapid changes in adhesive formulations and procedures have improved the convenience and reliability of bonding systems. Recent advances in the field of material sciences have opened up a new horizon of options for bonding agents that can be used efficiently in orthodontics.

**Keywords:** Bonding materials, bonding systems, adhesives.
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## Introduction

The evolution of orthodontic materials in the past 5 decades has been a unique progress curve characterized by periods of intense activity with many developments followed by long quiescent intervals. Orthodontic treatment was revolutionized with the development of the acid etch technique.

The acid-etching technique is still being employed for bonding brackets labially or lingually to enamel, albeit with potential variation as (a) in the case of self-etching where primers are incorporated into the acid solution or (b) moisture-insensitive and moisture-active adhesives where primers supposedly tolerate the moisture, or a functional component reacts with the moisture present in the surface of the tooth to achieve bonding.[1]

After the initial large-scale application of bonding in orthodontics, various problems gave rise to concerns for the integrity of enamel. Enamel involvement in etching-mediated bonding takes place at three stages:

At the etching stage, the structure and superficial composition of the tissue is permanently altered.

During the course of treatment, there is no exchange of ions with the intraoral environment for the enamel portion covered by the adhesive, with often the potential for demineralization.

During debonding, the use of rotary instruments to remove the adhesive results in the development of scratches on the enamel surface, which often outweigh the differences in color change induced by etching- and nonetching -mediated bonding.

The first category of concern has been long investigated, and efforts to replace etching with another mechanism have appeared, with varying degree of success. Since the mid 1980s, there has been a distinguishable trend in the literature to explore alternative bracket bonding means through several mechanisms employing calcium salts or nonetching mediated bonding. These efforts did not show acceptable results, and no further development on this issue was seen. Glass ionomer cements, with or without the use of polyacrylic acid etching, were adopted to replace orthophosphoric acid etching. Polyacrylic acid induces a significantly shallower depth of penetration (5-7 µm) relative to conventional acid etching; however, the clinical success is still debatable. To avoid the effects induced by the presence for an extended time of bonded appliances in the oral cavity, several protocols for remineralization, including the use of glass ionomers, fluoride-releasing materials, and primers, have been developed.[3]

Today, growing efforts are made to simplify and shorten the bonding procedures. Rapid changes in adhesive formulations and procedures have improved the convenience and reliability of bonding systems.

**Enamel Preparation**:

Acid etching, Crystal growth, Laser, or Air abrasion? The steps of direct or indirect bracket bonding on facial or lingual surfaces of teeth are as follows: cleaning, enamel conditioning, sealing and priming and bonding. Isolation of the operative field is followed by etching of the enamel surface. An untouched enamel surface is hydrophobic, and wetting is limited, which makes bonding to an intimate enamel surface a challenging procedure. An enamel pretreatment or surface conditioning is necessary to make successful bonds. This pretreatment is usually accomplished by etching the surface using various acids.

The most commonly used etchant is 37% orthophosphoric acid for 15 to 30 seconds. It is rinsed off with abundant water spray for about 15 sec. If salivary contamination occurs rinse with water spray & re etch for another 10 sec .Dry the tooth thoroughly to obtain dull frosty white appearance. 10% Maleic acid was introduced as an alternative etching material in the early 1990s in an attempt to control the depth of the enamel etches.The use of 10% and 20% polyacrylic acid for bonding was introduced by Smith - found that polyacrylic acid cements adhered to dental enamel because of the interaction of the aqueous polyacrylic acid component with the enamel surface. The most commonly used porcelain etchant is 9.6% hydrofluoric acid in gel form. Although etching times vary anywhere from 1 to 2 minutes, this porcelain etchant has been reported to yield satisfactory results, and the gold standard seems to be 2 minutes, followed by silane application.[1]

The considerable amount of data on the effect of bonding on enamel stimulated the development of alternative methods of appliance retention onto enamel. Among the techniques and materials tried, the most prominent was the Crystal growth system. This method, originally developed by Maijer and Smith at the University of Toronto, attempted to reduce the depth penetration of treatment into enamel; however, the bond strength provided by this system was considered inadequate at that time.

More recently, to improve the retentive properties of the adhesive to the enamel

during bonding, Espinosa et al deprotenized the enamel surface using 5.25% sodium hypochlorite (NaOCl) before applying phosphoric acid - this technique increased both the quality of the etching pattern as well as the surface area of the enamel available for proper bonding.

Some investigators have recommended extended enamel conditioning with phosphoric acid when bonding composite resin to fluorosed enamel to remove the acid resistant hypermineralized surface layer and increase SBS to enhance the bond strength of the brackets and to save chairside time. One of these materials is Enhance LC (Reliance, Itasca, Illinois, USA).[9]

Other research efforts focused on developing new techniques or adopting materials from restorative dentistry and transferring them to orthodontic bonding. Thus, the feasibility of air abrasion, Scotchbond primers, and various acids such as maleic were tested, but these applications did not find wide acceptance, although the results looked promising.

The manufacturers claim that it significantly increases adhesion of resins to fluorosed, hypocalcified, or primary enamel. The Er:Cr:YSGG laser induces micro cracks in the enamel surface that enhances bond strength also reduces caries susceptibility by modifying the calciumphosphate ratio of the enamel, leading to more stable and less acid soluble compounds. In an effort to reduce the number of steps involved in the bonding procedure, researchers evaluated whether the acid conditioner could be combined with the priming agent, thus reducing the bonding procedure by one step.[6]

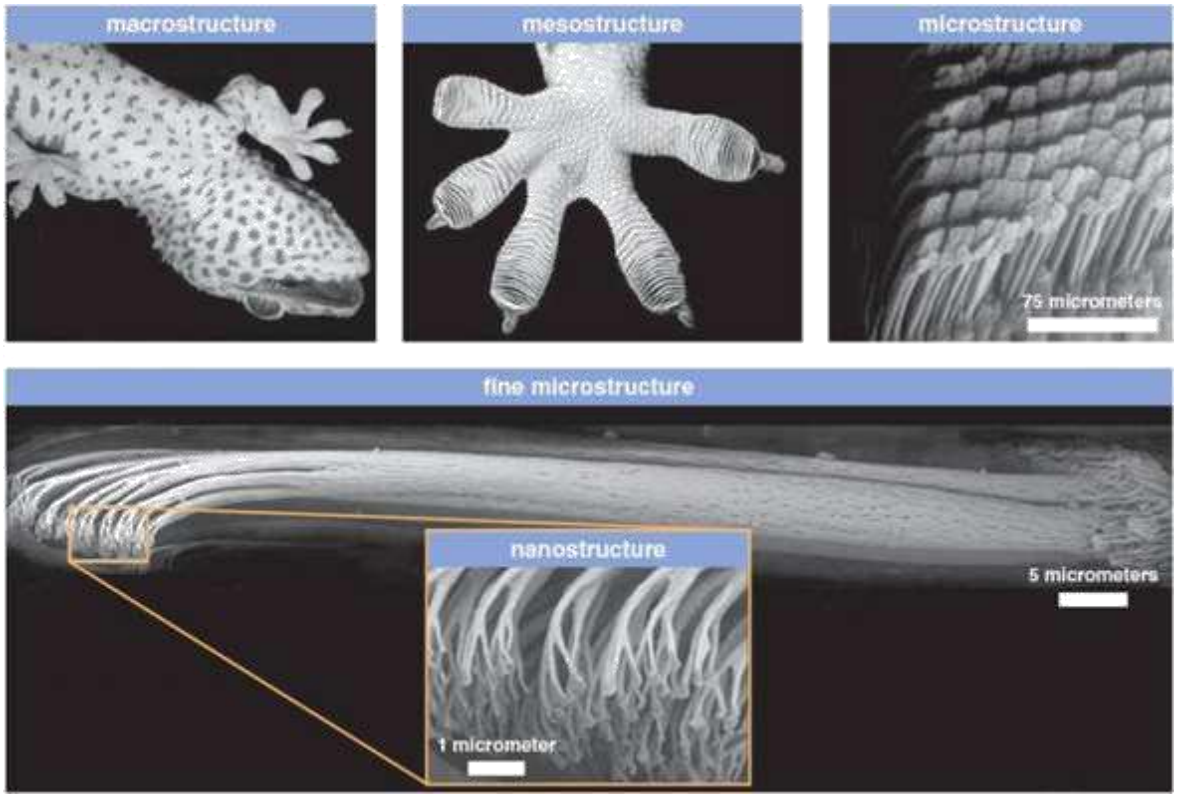


**Fig 1: The foot of a gecko has a flat pad which is densely packed with very fine hairs that are split at the ends, resulting in a greater number of contact points than if the hairs were not split.**

Lately, self-etching primers have received wide interest, and their use has gained popularity. Etching with self-etching compounds has proven effective despite the morphologic variation of the interfacial properties of conventional and self-etching enamel. Scanning electronic microscopic studies showed that self-etching yields shorter resin tags, which nonetheless might be adequate for orthodontic bonding, because resin tag length is not a determinant of bond strength. Overall, self-etching primers have been found to perform acceptably during treatment; however, contradicting evidence still exists on this issue, and more research is needed to establish the degree of cure and potential cytotoxicity of primers. Because of the retention of the acidic primer in the polymer structure, care should be exercised during application of primers to avoid mucosal irritation.

The active ingredient of the SEPs is a methacrylate phosphoric acid ester that dissolves calcium from hydroxyapatite. Rather than being rinsed away, the removed calcium forms a complex and is incorporated into the network when the primer polymerizes.

In an attempt to reduce the bond failure rates under moisture contamination, hydrophilic primers that can bond in wet fields (Transbond MIP, 3M Unitek, Monrovia, CA; Assure or Assure Plus, Reliance Orthodontic Products, Itasca, IL) have been introduced as a potential solution.

In 2010, voco America introduced voco futurabond DC as 8th generation bonding agent, which contains nanosized fillers. These new agent from self-etch generations have an acidic hydrophilic monomers and can be easily used on the etched enamel after contamination with saliva or moisture. The type of nano-fillers and the method that these particles are incorporated affect the adhesive viscosity and penetration ability of the resin monomers into collagen fibers spaces.[10]

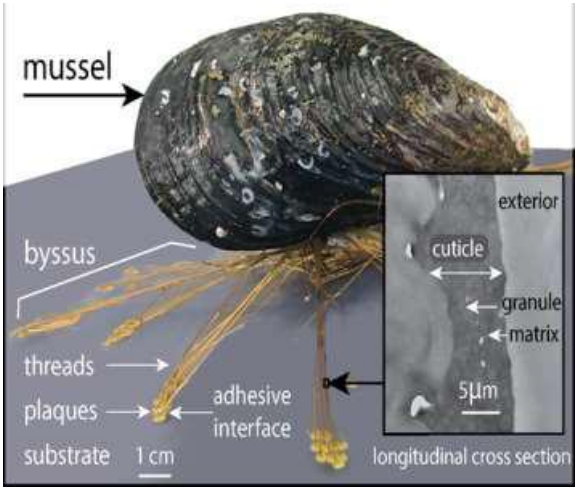


**Fig 2 : Mussel-mimetic polymers have an amino acid called L-3, 4-dihydroxyphenylalanine (DOPA) found in high concentrations in the 'glue' proteins of mussels**

To overcome the weakness of previous generations of single-step self-etch adhesives, universal adhesives have been developed in 2011 that allow for application of the adhesive with phosphoric acid pre-etching in the total etch or selective-etch approaches in order to achieve a durable bond to enamel. (a technique commonly referred to as "selective enamel etching")

Methacryloyloxydecyl Dihydrogen phosphate (MDP) is a hydrophilic monomer with mild-etching properties. It helps to promote strong adhesion to the tooth surface via formation of non-soluble Calcium salts.[11]

**Adhesives**:

2-phase, no-mix, or light-cured? During the past decade, adhesives with antimicrobial properties and moisture-resistant or water-

activated features were also introduced, and the literature has also dealt with varnishes and fluoride-releasing materials to inhibit microbial colonization around brackets and reduce the risk of decalcification. Glass ionomers and resin-modified glass ionomers have been used for that purpose with relatively high success.[3]

The 2-phase products were the first to be tried by orthodontists in the early days of bonding. Handling and applying these materials is problematic, time consuming, and cumbersome, and they are gradually being eliminated from active orthodontic practices. Mixing the 2 components introduces potentially critical defects such as surface porosity and air voids in the bulk material, because of the prolonged exposure to air and the inevitable entrapment of air bubbles, which adversely affect polymerization because of the inhibition of the reaction by the oxygen in the atmospheric air. Studies have shown that light-cured composites, intentionally mixed as if they were chemically cured materials, had severely porous surfaces and air voids in the bulk material. However, the long term effects of porosity have detrimental implications for the integrity of the polymer network, which shows degradation and release of monomers. The principle of inhomogeneous polymerization was introduced in orthodontics with the development of the no-mix adhesives, which were intended to minimize the mixing-induced defects and reduce the steps required for placement of the material. In these systems, a catalyst gradient is established from the primed enamel surface toward the brackets, by means of a diffusion process. Under these conditions, resin strength is decreased by the establishment of a disturbed cross-linked network, which nonetheless can facilitate bond strength, similar to conventional systems.[5]

In light-cured adhesives, for a given monomer system, the extent of polymerization depends on exposure time, photoinitiator concentration, light intensity of the curing unit at the peak absorbance wavelength of the photoinitiator, and filler volume fraction, which can induce refraction and scattering of light, thereby reducing its intensity in the bulk material. The spectral distribution of the light source significantly affects the polymerization material, and thus the intensity given by the manufacturer should be read at the peak absorbance wavelength of the initiator, which for most systems is 468 nm .The widespread use of light-cured adhesives, the gradual decline of 2-phase systems, and the development of moisture-insensitive primers, water-activated adhesives, and antimicrobial properties are the main developments over the past 10 years.[6]

**Future of Bonding**

- *Command-debond adhesives*

The removal of resinous adhesive after debonding is still an issue of interest. The mass of adhesive left on the enamel could be controlled to some extent by altering the adhesive bracket interfacial characteristics to enhance the interfacial strength by varying the filler content and bracket base retentive characteristics. However, the use of burs poses an unfavorable effect on enamel integrity in two ways: (a) the generation of aerosols, which consists of particles in the range of 2.5 mm that could be inhaled and (b) the potential estrogenic action of these particles of adhesive, owing perhaps to the large surface-to-volume ratio and the effect of heat shock on the adhesive, which releases bisphenol A (BPA) under these conditions..

A potential solution to this problem could be the development of command-debond adhesives. These are polymers in which the polymerization can be "reversed" using the following strategies: (1) irradiation with a specific wavelength capable of drastically lowering the glass transition temperature of the polymer, thereby initiating transformation to a viscous state and allowing for removal of the nonglassy adhesive, or (2) incorporating a filler that could be employed to cause severe structural alteration of the material upon specific application of a stimulus.[7]

- *Bisphenol A-free monomers*

The majority of orthodontic adhesive materials are derived from BPA. The BPA configuration assembles a bulky, stiff chain that provides low susceptibility to biodegradation, as well as significant strength and rigidity in BPA-derived dimethacrylate polymers based on monomers such as bisphenol A glycidyl dimethacrylate (BisGMA), its ethoxylated analog (BisEDMA), bisphenol A dimethacrylate (BisDMA), and urethane-modified BisGMA. Although BPA is not used as a raw material in dental composite resins, it is likely to be present as an impurity from the chemical synthesis procedure. This model of action originates from natural human hormones, such as 17b-estradiol, which can generate effects at concentrations markedly lower than those required to block the specific receptors. BPA, and BPA derivatives, increase the levels of reactive oxygen species, which are known mediators of signaling cascades under physiological conditions. Elevated levels of such compounds can disrupt the cellular redox equilibrium, causing oxidative DNA damage and apoptosis in mammalian cells.[3]

Xenoestrogenicity is a relatively recently described property of certain polymeric molecules such as BPA to express biologic effects similar to those induced by natural estrogens. The similar chemical structure of BPA to natural estrogen (17-beta estradiol) is the reason for this deviation of the hormonal homeostasis from the proper pathway. Reports demonstrating BPA's effect on thyroid hormones as well as reduction in testosterone levels in boys have also been published. All hormone mimicking effects can lead to obesity, widespread fertility problems, feminization of boys, accelerated maturational changes in girls, and increased diabetes risks and breast cancer incidences.[4]

In orthodontics, BPA dimethacrylate derivatives are mostly used for bonding brackets (bonding resins and composite resins as main adhesives) and lingual retainers, whereas BPA-polycarbonates are used for manufacturing plastic brackets. In vitro studies have documented the release of BPA from polycarbonate brackets, orthodontic adhesives, and the composite resins that are frequently used for bonding lingual retainers. For traditional and flowable composite resins used as lingual retainers, BPA release was confirmed in vivo as well, with the highest values in saliva measured immediately after polymerization. Efforts have been undertaken to replace the BPA monomer derivatives by other BPA-free monomers, with the objective of matching the well-established polymer network stiffness, strength, rigidity and low biodegradation susceptibility of BisDMA derivatives. Most alternative approaches included aliphatic comonomers based on triethylene glycol dimethacrylate, urethane dimethacrylate, and cycloaliphatic dimetha-crylates, all introduced from restorative

composite resin technology, along with proper filler particle reinforcing agents. Although conventional orthodontic adhesives are mostly used for bonding metallic wires to enamel, there are still several issues to be addressed.[12]

New monomers have been introduced based on a non-BPA synthesis route. These involve (1) single aromatic-ring, highly reactive, multifunctional monomer [phenyl carbamo-yloxy-propane dimethacrylate (PCDMA)] that is incorporated, along with conventional aliphatic comonomers and glass fillers, or (2) the use of aromatic-free urethane dimetha-crylate monomers. The two experimental BPA-free materials have demonstrated better degree of cure and less extent of water plasticization compared to the control, which was based on a BPA-compound (BisGMA). The control demonstrated higher mechanical properties, but no statistically significant difference in pullout strength from the two experimental materials. Considering the differences between the two experimental materials, it may be concluded that the material containing the monoaromatic dimethacrylate derivative (PCDMA) with higher hardness and elastic modulus may be used as an alternative to the control.[8]

- *Biomimetic adhesives*

The issue of an enamel-friendly bonding mechanism for orthodontic appliances has been the subject of investigations since the original introduction of the acid-etching technique. This intense interest derived from the description of alterations of enamel color and structure associated with acid-etched mediated bonding. The introduction during the past 15 years of a new class of materials that adopt the paradigms of nature has gradually established the category of biomimetic materials. This term derives from Greek "bio" (living) and "mimetic" (imitating or resembling) and refers to how creatures ingenuously employ natural elements to solve problems in the environment. Geckos, for example, are lizards that belong to the species of gekkonidae and are characterized by a remarkable ability to sustain their weight while upside down. The strong but temporary adhesion employed by a gecko comes from a mechanical principle known as "contact splitting." The foot of a gecko has a flat pad that is densely packed with very fine hairs that are split at the ends, resulting in a greater number of contact points than if the hairs were not split as shown in fig.1. More contact points between these hairs and a surface result in a significant increase in adhesion force.[5]

Researchers have discovered that this special nature of the foot pads allows the gecko to stick to surfaces through the formation of localized van der Waals forces. This mechanism has been employed for high-friction microfibers or carbon nanotubes, which are sprayed on a surface. Because of their enormous number per unit area, the physical forces developed mimic the ability of a gecko to attach firmly to surfaces without the use of a chemical substance. While this mode of bonding may be suitable for dry environments, it fails to provide reliable performance for wet surfaces. This problem inspired researchers to adopt another natural example of bonding: that of mussels.

Combining the important elements of gecko and mussel adhesion, the new adhesive material, called "geckel," functions like a sticky note and exhibits strong yet reversible adhesion in both air and water. Mussel-mimetic polymers have an amino acid L-3, 4 dihydroxyphenylalanine (DOPA) that is

found in high concentrations in the "glue" proteins of mussels as shown in fig.2. Analogously to the gecko-based approach, pillar arrays coated with the mussel-mimetic polymer improved wet adhesion by 15-fold over uncoated pillar arrays. Brackets having bases with pads mimicking the gecko foot and covered with a layer of DOPA would provide adequate bond strength to sound enamel without prior enamel conditioning and with minimal color and structural alterations to the enamel.[7]

- *Self – healing materials*

The design and manufacturing of smart, self-healing synthetic systems that can mimic the behaviour of biologic systems that heal themselves has been an objective of intense research during the past decade. Hybrid materials have been recently created, where micron scale conduits extend throughout the material and contain healing fluids or dissolved healing agents. When a crack appears near the network, the fluid can flow to the damaged region and fill the fissure .The simplest form to achieve this behavior might be the incorporation of bubbles of a material, substance or precursor in the raw material. This reservoir, upon exposure to air, polymerized as a result of crack formation and spontaneously closes the crack, thus maintaining the structural integrity of the material as shown in Fig.3.

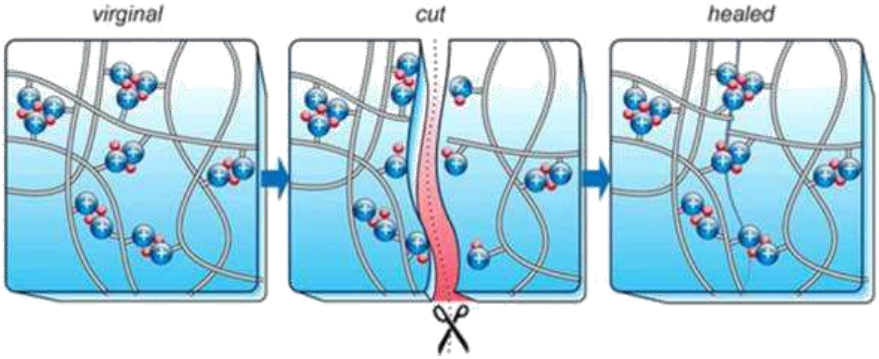


**Fig 3 : When a crack appears near the network, the fluid can flow to the damaged region and fill the fissure. This reservoir, upon exposure to air, polymerizes as a result of crack formation and spontaneously closes the crack, thus maintaining the structural integrity of the material.**

The orthodontic application of this concept may involve polymer brackets and archwires. The integration of nanosized bubbles filled with autopolymerized monomer in these materials may result in fewer wire and bracket breakages. Fracture of the bracket or wire would induce bursting of the nanobubbles and exposure of the monomer to air thereby resulting in polymerization and filling of the crack-induced gap.[5]

- *Self –cleaning materials*

The issue of plaque retention on brackets and microbial attachment onto these calcified biofilms has been a major concern from an enamel prophylactic perspective.

The development of a material that could clean itself not only from mainly inorganic, but also from mainly inorganic,but also from organic, precipitations is an attractive application in the materials science ares involving biomedical, industrial and aeronautical applications.

Early research in this field adopted the paradigm of microscopic bumps on a lotus leaf tat transform its waxy surface into an extremely water repellent, or super-

hydrophobic material. Synthetic self-cleaning materials have been developed, some of which are based on this "lotus effect", whereas others use the opposite property of "superhydrophilicity" as well as catalytic chemical reactions.

Photocatalytic activity from the reaction of titanium oxide with ultraviolet light has recently gained attention in orthodontic materials. There is a scientific interest in inducing photocatalytic reactions on the nickel-titanium archwire alloy. By thickening the titanium oxide film with electrolytic treatment and then applying heat, the surface film on the nickel-titanium alloy was modified from an amorphous structure to crystalline rutile (titanium dioxide). [5]

**Conclusion**

Improved adhesive materials have made resin-based composite restorations more reliable and long standing. As we enter the new millennium, it is important to examine the past keeping abreast of the fast rapidly spreading advances in the practice of adhesive dentistry with the latest trends.

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