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Recent Advances in Dental Materials

[1]Dr. K. Anusha Ravindra, [2]Dr. Malathi Dayalan
[1] *III MDS Student,Department of Prosthodontics and Crown &Bridge,The Oxford Dental College,Bangalore,India.*
[2] *Professor and HOD, Department of Prosthodontics and Crown &Bridge,The Oxford Dental College,Bangalore,India.*

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ABSTRACT: Science is undergoing great revolutions that are leading us to a new era of dentistry. The development and implementation of any new system relies on comprehensive understanding of the existing systems.In the prosthodontic treatment of missing teeth, artificial materials are used as dental materials to restore oral function. Any dental material used in the oral cavity must satisfy the basic pre-requisites: - similar mechanical and physical properties, resist masticatory forces, improve functions and aesthetics. With the improving awareness of patients regarding the advances in dentistry and oral health, the demand for such dental materials has diversified. With the beginning of the 20th century, there came many refinements and improvements in quality of various materials and processes used in dentistry. Physical and mechanical tests combined with fundamentals of engineering science were applied to structure designs and restorative materials. Shortcomings of materials were recognized and improved by the advent of newer technology. Therefore, intensified efforts were made to invent and improve products with required properties designed for specific purposes. The present study is a review of recent advances in dental materials.

Keywords: recent advances, dental materials, polymers, dental cements, implants, maxillofacial materials.

I. INTRODUCTION

Life style has undergone various changes starting from discovery of wheels and fire to revolutionary invention of super computers and aircrafts that defy all the laws of gravity. Dentistry has come a long way from just replacing missing teeth to replacing lost alveolus supporting facial structures, recreating aesthetics, re-establishing phonetics and many other major developments. With the beginning of the 20th century, there came many refinements and improvements in quality of various materials and processes used in dentistry. It would be hard to imagine a field in dentistry that has undergone a more explosive evolution than that of dental materials. Research in dental materials involved modification of existing materials or development of new and better materials for prosthetic applications. The goal of research has been to replace or restore lost or damaged tooth structure satisfying aesthetic and functional requirements. Hence it is important for dentists and patients to understand both the advantages and limitations of dental materials to allow the selection of the best dental material.

ElastomericImpressionMaterials

1)**Vinyl Polyether Siloxane (VPES)-** This new elastomer combines features of both addition silicone and polyether. This material has to be used only in a one-step multiple mix technique. It is available in viscosities of medium (Monophase), heavy and light body. Its advantages include:1)Excellent flowability 2)Remarkable hydrophilicity 3)Balanced setting behaviour 4)Dimensionallyaccuraterecovery.

2)**SENN**- is a new generation hybrid impression material that optimizes the best properties of both polyethers and vinyl polysiloxanes. Its surfactant free chemistry maximizes pickup and decreases lustre allowing for ease of use, accuracy and improved viewing of detail. SENN maximizes hydrophilicity before set allowing for excellent fluid displacement, minimizes voids and bubbles and provides a crisp pickup of details. The Hybrid VPS Technology eliminates smell and provides improved taste, elasticity and dimensional stability.

3) **Fit Checking Silicones**: - are Vinyl Polyether Silicone (VPES) materials that are ideal for fit-checking dentures, PFM (Porcelain-Fused-to-Metal) Restorations, ceramic prosthetics and occlusal contacts. Its products provide optimal flowability, excellent detail and accuracy that is not affected by saliva. The minimal film thickness provides excellent transparency for easy fit-checking. It peels away easily, leaving a clean, residue-free fitting

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surface. In-office adjustments are convenient and time-saving for all patients.

4) **Bite Registration Silicones: -** syringeable addition-curing elastomeric bite registration materials intended for making accurate occlusal records.

5)**Silginat**-is an addition-curing, elastomeric polyvinyl siloxane (PVS) impression material to be used as an alginate alternative in a variety of anatomic impressions. It was designed with a low-tear resistance to avoid inadvertently dislodging restorations or orthodontic appliances while providing excellent palatal definition and detail. Silginat has an optimized medium flow viscosity with heavy body hardness when set. Silginat is also highly thixotropic and flows properly under pressure, giving it an ideal workability. The thixotropic nature of the material also helps prevent patient gagging.Silginat has a high dimensional stability so gypsum or model stone impressions can be poured immediately or kept for days or weeks without sacrificing accuracy. In addition, multiple models can be poured from just one impression with accuracy (three to four times depending on technique). Silginat's flexibility is an excellent time-saving device for practitioners, allowing them to dictate the optimal time to pour their impressions.

6) **Visible light cured polyether urethane Di-methacrylate: -**provide a bubble free single component paste for dental impression taking, provide a low shrinkage impression paste for obtaining accurate impressions,an impression material which can be cured by exposure to visible light of the appropriate wavelength in the range of about 400-600 nanometres.

7) **Polyjel NF**- Elastic Polyether Impression Material Type 2 Medium Viscosity. lt is a prompt setting, hydrophilic, monophase, polyether type elastomeric impression material that provides optimum performance, exceptional dimensional accuracy and stability.

Hydrocolloids

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. 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.
2) **Alginate in the form of two-paste system-** Alginates were developed in two-pastesystems to prevent the contamination of powder, and inconsistency in dispensing a certainamountofpowder.
3) **Chromatic alginates (Alginates with colour indicators)** -The problem observedamongsomeoftheundergraduatestudentsisdifficultyinidentifyingtheidealconsistencyofalginatematerialduringmanipulation.Variouscolourindicatorswereaddedtothealginateimpressionmaterials to identify the different stages of manipulation.
4) **Self-disinfected alginates-** It was reported inthe literature that the conventional disinfection procedures such as immersion and sprayingmethods which may lead to the unwanted dimensional changes in the alginate impression asthey were hydrophilic. Addition of disinfecting agents into theimpression materials eliminates separate disinfection of the impression immediately afterremoving it from the patient's mouth.
5) **Extended pour alginates**- Due to syneresis and imbibition, it is unable to store thealginate impression for a longer duration. Attempts made by the manufacturers to address thisproblemledtothedevelopmentoftwonewalginatematerialssuchasCAVEXColourChange(Darby Dental Supply, USA) and Extend a Pour (Dux Dental Products).
6) **Alginatewithpolyacrylamideincorporation**- 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) was incorporated into the conventional alginates resulted in improving the mixing characteristics, and the formation of smooth alginate sol with water

Gypsum products

1) **Disinfectingadditivesfordentalstone-**

Dental casts come into direct contact with impression materials and other items that arecontaminated by saliva and blood from a patient's mouth, leaving the casts susceptible tocross-contamination. Calcium hypochlorite was chosen as an additive because of its well-known disinfectionproperties, and because it was hypothesized that the calcium salt would have less effect onstructureand properties ofcalcium sulfate dihydrate comparedto sodium hypochlorite.

DentalWaxes

1) **Lightcuredwax:-** The Metacon light cured wax is a unique chemical composition of cracked

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carbon chains(acrylic)withphotoinitiatorsattachedtobothendsofthecarbonchainpieces.Theseconditioned acrylicpartsarethenmixed withspeciallyformulated waxes.The light cured Metacon material has a memory, whichmeans that when it is flexed italways goes back to the original position it has been polymerisedinto. Due to this"Memory-Effect" the partial can be lifted off and placed back onto the model as desired.

2) **AestheticWaxes**:-

The Aesthetic Waxing Kit helps to prepare full diagnostic wax-ups in lifelike natural tooth colours andopacities.

- **Ivory Opaque Sculpturing Wax**- At the centre of the colour wheel, Ivory ismainly used as an opacifier and diluent for the highly chromatized waxes to simulateopalescent effects.
- **Pink Opaque Sculpturing Wax** -Pink may be used to simulate gingival tissueand to create incisal effect colour.
- **Blue Sculpturing Wax**- Intensify the translucency of the incisal portion of thesculpturewithBlueSculpturingWax.
- **TranslucentSculpturingWax**- UseTranslucenttosimulatethenaturalappearance of incisal enamel.
- **Brown Sculpturing Wax**- Used mainly for fossa definition, Brown SculpturingWax adds depth and detail to the posterior fossae, as well as anterior lingual cingulumfossae.
- **Tan Opaque Sculpturing Wax**- Added to sculptured tooth in the area of thegingivalonethird,Tansimulatesthenaturaltooth'sgingivalcolour.
- **Dentin Sculpturing Wax**- Used to simulate dentin structure, DentinWaxmayalsobeusedtocreatedentinreflectionthroughthe incisal edgeby placing asmall amount on thelingual incisal.
- **Yellow Sculpturing Wax**- Use this versatile wax to intensify gingival colour,simulate root structure, highlight lingual cingulum dentin, accent reflection of dentinshowingthroughtranslucentincisal,createinterproximalshadowing,andhighlighttheocclusal fossaeof posterior crown sculptures.
- **Red SculpturingWax**- ThecombinationofRepSculpturingWaxandPink Opaque simulates natural gum tissue. It can also be blended into the Ivory Wax to addvitality to thesculptured form.

3) **SCANWAXES**- CAD/CAMopaqueisaScanWaxforCAD/CAMis aspeciallyformulatedlaser-opaque and light-opaque wax for sculpturing according to the CAD/CAM procedure.

4) **The WAX-O-DENTAL FULL CONTOUR PONTICS™**- prefabricated solidpontic wax bridges for wax-ups of pontic areas for diagnostic models, gnathological wax-upsand temporary bridgework gathers a selection of 104 forms from the Total Assortment of 224forms incorporated in 6-unit (13-33,43-33) and 4-unit anterior andposterior solid pontic waxbridgeswithprefabricated occlusion.

Materialsforcutting,grinding,finishingandpolishing

1) **Air-Particle Abrasion Technology**- As an alternative to the use of rotary instrument, air-particle abrasive systems are minimal invasive technologies that can deliver a definitely controlled high - pressure fine stream of 25µm to 30µm aluminium oxide ($Al_2 O_3$) or silica particles to remove decayed or stained enamel, dentin, and restorative materials.

2) **Profin PDX System**- Profin PDX system comprises of a contra-angle handpiece usingreciprocal motion with special finishing and polishing tips - Lumineers LTA (Dentatus AB,Sweden). This system is mainly indicated for elimination of overhangs, contouring, grinding,andsmootheningofrestorationsparticularlyinthesub-gingivalandinterproximalregions.

3) **Abrasive-ImpregnatedBrushes**-These polishing brushes are available in few shapes (pointed, cup-shaped), with an assortment of polymer ''bristles'' impregnated with different types of abrasive particles. These flexible brushes aim for reaching into the detail grooves, protrusions, patterns, and other inaccessible interproximal areas of ceramic and composite resin restorations.

4) **Rotary Polishing Tools**-Rotary tools designed on basis of a polymer or composite resin composition or matrix, with controlled grinding have recently come into limelight for their specific action on removal of surface adherent restorative materials, including composite resin and surplus cement.

5) **Nanotechnology Liquid Polish**-This new paint - on - polish adds a smooth, dazzling finish toany composite or temporary restoration.

MaterialsforGingivalRetraction

1) **Expasyl** -Expasyl is a biocompatible material which presents with advantages of having

excellent retraction with longer shelf life. It is known to physically displace the tissue for better marginal access. Minimal pressure required to displace the tissues. It does not pose hazard of rupturing epithelial attachment. It also produces haemostasis and controls crevicular seepage.

2) **Magic Foam cord** - Magicfoamcordisapolymericmaterialwhichisintroduced into the gingival sulcus and allowed to set. Magic Foam cord presents with efficient haemostasis and minimaldamagetotissueswhileretraction. Magicfoamcordretractionsystemwasconsidered moreeffectivegingivalretractionsystemamong theotherthree.
3) **Gingitrac**- GingiTracuses an automixingguntodelivertheperfectcombinationofmildbuilt-inastringencytocontrolhaemostasis. It is an effective gingival retraction system based on vinyl polysiloxanematerialwithaluminiumsulfateastringent.
4) **Gel-CordGelcord**- comprisesof-25%AluminiumSulfateGel. It is indicated for Class V Restorations or if tissue is altered duringcomposite placement.
5) **TissueGoo**-TissueGooisagelthatcontains activeingredientis25%aluminiumsulfatestaysput where itisplacedandprovidesample haemostasisduringtissue. 6 6)
6) **RetractionCapsule**- Therecentlyintroduced3M™ESPE™Retraction Capsuleis15%aluminium chloride retraction paste.
7) **Lasers**-There are different types of lasers used andbased on power, they can be classified as

I. High-power lasers (hard, hot)
II. Intermediate-power lasers:
III.Low-powerlasers(soft,cold)

DentureLiners

1) **AdditionofSilverNanoparticles**- Oneoftheproblemsencounteredwhileusingsoftdenturelinersisthegrowthofmicroorganisms. Microorganismsinitiallyadhereto thesurfaceoftheliningandthentheypenetrateinsidethematerial. ModificationofsoftliningsbyAgNPscanbeusedbecauseoftheirfungicidalandbactericidalproperties of silver.
2) **Incorporation of Antifungal Agents**- An antifungal agent incorporated into a tissueconditioner can provide a slow continuous release resulting in a sustained therapeutic effect.

BondingAgents

1) **Adhesive material with anti-matrix metalloproteinase functions:** - On theapplication of MMPs inhibitors as components of the adhesive system, a bond system isprovidedwithimproveddurabilityoftheadhesive restoration.
2) **Adhesive with remineralization function**- The adhesive system with a capacityof remineralization is believed to increase the longevity of adhesive restoration using healingmicrocracksandtoneutralizeacidicacidsin adhesivejoints.
3) **Antibacterial bonding system**- The addition of antibacterial primer can help to killresidualbacteriainthetoothcavity;thus,antibacterialbonding agentscancombattheissueofbiofilms and recurrent caries at tooth and composite interface. Thus, the addition of nanoparticles of silver can have ahighsurfacearea;lowerfillerlevelcanprovideadequateantibacterialeffectswithoutaffectingthecolourof restorationand mechanical properties of dental adhesives.
4) **Zinc Doped Adhesives**- Zinc-dopedadhesivescanbeobtainedbyusing20wt%ZnOor2wt% $ZnCl_2$ without altering adhesive physic, chemical and mechanical properties. zinc doping improves sealing efficacy and dentinremineralization.The$slowZn^{2+}$liberationwillfacilitatetheformationofaZnOrichlayerthatpermittingCaand P deposits and furtherremineralization.
5) **Hesperidin**-HPN, a protein cross-linking agent has been employed in modifying Clearfil SE primer. HPN showed remineralization of the surface and the subsurface lesion. It could be deduced that besides the effect of protein cross-linking, HPN has the capability of enhancing dentin lesion remineralization in vitro.
6) **Doxycycline**- **Doxycycline**(DOX),atetracyclinederivative,iswidelyusedinthetreatment of various infectious diseases. DOX could inhibit cariogenic bacteria such as S.mutans, Lactobacillusacidophilus and Actinomyces.DOXisaninhibitorofMMPsbychelatingzincpresent inthecatalyticdomainof MMPs andtheenzyme-associated calcium.
7) **Chlorhexidine**- CHX,abiguanideantimicrobialagent,hasbeenbroadlyusedindentistryfor its microbial efficacy and substantivity. CHX is the most widely accepted non-specificMMPinhibitorevenataconcentrationof0.

05wt% CHXnotonly caninhibitMMPs butalso electrostaticallybindsto demineralizeddentin.

8) **Antibacterial Bond System**- The agents used to modify adhesives have differentantibacterial mechanism. Ag ions could interact and inactivate the vital enzymes of bacteria, and cause the DNA in thebacteriato loseits replication ability, leadingto cell death.
9) **Alcohols**- By forming a coordinate covalence bond between the MMP's catalytic zinc and the oxygenatom of the alcohol's hydroxyl group and the bonding might be attributed to the hydrophobicnatureofalcohols.
10) **Collagen Cross-Linking Agents**-Protein cross-linking agents were proposed toinduce conformational changes in MMPs 3D structure and cause MMPs to lose molecularmobility. At the same time, protein cross-linking agents may stabilize collagen matrix andimprove the mechanical properties of the hybrid layer, thus strengthening the resin-dentinbond.

ResinBasedComposites

1) **Condensable/packable or polymeric rigid inorganic matrix material**- Thissystemiscomposedof a resin matrix and an inorganic ceramic component. Rather than incorporating the fillerparticles into the composite resin matrix, devised a unique system by which the resin isincorporated into the fibrous ceramic filler network. This mainly consists of aluminium oxideandsilicondioxideglassparticlesorbariumaluminiumsilicateorstrontiumglasses.
2) **Flowable Composite**- A newer type of composite was released in 1996 that has beentermed a "flowable composite" because of its low viscosity and ability to be syringed into acavitypreparationwithaneedletip.
3) **Indirect Composite Resin**-. A number of highly improvedindirect resin restorative systems have been introduced with unusually good properties likewearresistance,aesthetics,marginaladaptation,controloverpolymerizationshrinkage.
4) **Nanocomposites**- Nanotechnology may provide composite resins with a dramaticallysmaller filler particle size that can be dissolved in higher concentrations and polymerized intothe resin system.
5) **AntimicrobialComposite**- Antimicrobialpropertiesofcompositesmaybeaccomplishedbyintroducingagentssuch assilveroroneormoreantibioticsintothematerial. Microbes are subsequently killed on contact with the materials or through leaching of theantimicrobial agents into the body environment.
6) **Stimuli Responsive Composite**- Stimuli-responsive materials possess properties thatmay be considerably changed in a controlled fashion by external stimuli. Such stimuli may befor example changes of temperature, mechanical stress, pH, moisture, or electric or magneticfields.
7) **Fibre Reinforced Composite**-. Over the years, these materials have evolved to the extent that they can be used for both direct and indirect restorations.
8) **Self-healing Composite**- Materials usually have a limited lifetime and degrade due todifferent physical, chemical, and biological stimuli. Oneofthefirstself-repairingorself-healingsyntheticmaterialsreportedinterestingly shows some similarities to resin-based dental materials, since it is resin-based.This was an epoxy system which contained resin filled microcapsules.
9) **Organically modified ceramic oligomers (ORMOCER)**- ORMOCER is anacronym for organically modified ceramics. They are considered to be molecule-sized hybridstructures consisting of inorganic, organic copolymers. They include; limitedcureshrinkage,veryhighbiocompatibility, goodmanipulationproperties,andexcellentaesthetics.
10) **BellglassHP**- BellglassHPisanindirectrestorativematerialwhichwasintroducedin1996 by Belle de St. Claire. These materials have increased polymerization rate as they arecured under pressure (29 PSI) at an elevated temperature of 1380C and in the presence ofnitrogen gas.
11) Art glass- Art glass is a nonconventional dental polymer marketed since 1999. It iswidelyusedinmakingindirectrestorationssuchasinlays,onlays,andcrowns.Thesematerialsexhibit improved wear resistance and other physical and mechanical properties due to thegreater level of crosslinking.
12) **Calcium phosphate nanoparticles**- Calcium phosphate such as Hydroxyapatitephosphate, anhydrous calcium phosphate, tetra calcium phosphate and dicalcium phosphateanhydrous have been used as fillers. Theincorporation of these particles improves stress-bearing capacity and ion release that inhibitdentalcaries.
13) **Bioactive glass nanoparticles**- These have excellent regenerative properties inmineralisedtissues.

Thesenanoparticlesinducetheformationof apatite in dentin.

14) **Amorphous Calcium Phosphate-**Based Bioactive Polymeric CompositesforMineralizedTissueRegeneration-Amorphouscalciumphosphate(ACP),apostulated precursor in the formation of biological hydroxyapatite.In addition to excellent biocompatibility, these composites providedsustained release of calcium and phosphate ions into simulated saliva milieus.
15) **Ionreleasingcomposites**-Ionreleasingcomposites,alsoknownassmartcomposites, releasecalcium,fluorideandhydroxylionsdependingonthepHchangeontherestorationsurfaces. Consequently, withan increase in the ions expressed, it was aimed to prevent the effect of bacteria, the bufferingcapacity and the formation of secondary decay which develops at the edges of the restoration.
16) **Siloranes**- Silorane-based composite resins were developed to increase the clinicalperformance of composites. The function of the oxyranestructureinthisreactionistoreducepolymerisationshrinkageandthesiloxanefunctionisthefor mationofahydrophobicstructure.
17) **Giomers**-Giomersarehybridrestorativematerialsformedfro mthecombinationofglassionomers containing active filling particles and composite resins. Giomers have advantages such as good aestheticproperties, being resistant, ease of polishing and being able to express and store fluoride.Giomers are bonded to the tooth surface through a bonding system like the composite resins.
18) **Self-adhering composites-**Incorporating acidic monomers into theself-etch adhesive systems is the same concept for self-adhering resincompositewhereinacidicfunctionalmonomersfavorabondedrestoration to adhere to the tooth tissues more than their ability todecalcify it which is known as the adhesion decalcification concept.(AD concept).
19) **Bulk-fill composites**- After the non-stoppingdevelopment and improvement of composite materials, a new randomized controltrial shows very favorable outcomes for direct composite restorations replacingocclusalcusps in the posteriorregion.

DentalCements

1) **Resin modified glass ionomer** - They were introduced in 1988 by Antonucciet al to overcome the problems associated with the conventional Glass -ionomers and at the same time preserving the clinical advantage of conventionalmaterials. They are a hybrid of glass ionomer and resin composites.
2) **Compomers**-(PolyacidmodifiedResincomposite)Itisformedby combinationofcomposites(COMP)andGlassionomers(Omer). Theycontaindi-methacrylate monomer and two carboxylic groups along with ion-leachable glass and absenceof waterinthecomposition.
3) **Condensable /Self-hardening GIC** - Developed in 1990's as filling material forART.Thesearepurelychemicallyactivatedresin modifiedglassionomercements(RMGICs)with no light activation at all. It is used mainly in paediatric dentistry for cementation ofstainless-steel crowns, space maintainers, bands and brackets.
4) **The Low Viscosity/Flowable GIC** - Fluoride recharge material: To overcome theshortcomings faced by fluoride releasing material, a new material has been developed forfluoride release. In order to improve the strength of these fluoride containing materials, if theyaremadedenserandstronger,thentheefficacy ofFreleaseisdecreased.
5) **BioactiveGlass**-thismaterialconsidersthefactthatonaciddissolutionofglass,thereisformationofalayerrichincalcium andphosphatearound the glass, such a glass can form intimate bioactive bonds with bone cells and get fullyintegrated with the bone.It is used in retrograde filling material, for perforation repair,augmentation of alveolar ridges in edentulous ridges, implant cementation, and infra-bonypocketcorrection.
6) **Fibre-reinforcedGIC**-Toimprovethedepthofcure,reducedpolymerizationshrinkage, improved wear resistance, and increase in flexural strength of GIC, alumina fibersare mixed with glass powder.
7) **Fibre-reinforcedGIC**-Toimprovethedepthofcure,reducedpolymerizationshrinkage, improved wear resistance, and increase in flexural strength of GIC, alumina fibersare mixed with glass powder.
8) **Proline-containing GIC**- It is an amino acid–containing GIC, which has better surface hardness properties.
9) **Calcium aluminate GIC**-A hybrid product with a composition between that of calcium aluminate and GIC, it is designe for luting fixed prosthesis. The calcium aluminate contributes

to a basic pH during curing, reduction in microleakage, excellent biocompatibility, and long-term stability and strength.

10)**Ceramir Crown & Bridge**-is a permanent, radiopaque, bio ceramic luting cement supplied in capsules. It is indicated for conventional cementation of metal-, lithium disilicate-, alumina- and zirconia-based restorations. The capsules contain glass ionomer powder and bio ceramic (calcium aluminate) powder plus water. Activation of the capsule with the Ceramir Activator is done prior to mixing in a 4000-5000 rpm mixer. Dispensing requires use of either the Ceramir Applicator, Aplicap Applier (3M ESPE) or the AC Applicator (VOCO).

Prosthetic Polymers and Resins-

1)**Reinforced resins**

a) **High impact resins**- Rubber reinforced (butadiene-styrene polymethyl methacrylate). Rubber particles grafted to MMA for better bond with PMMA. They are so-called because of greater impact strength & fatigue properties, hence indicated for patients who drop their dentures repeatedly e.g., parkinsonism, senility.

b) **Fiber reinforced resins:**

- **Metal fibre reinforced** -Not widely used because unesthetic, expensive, poor adhesion between wire & acrylic resin & metal being prone to corrosion. Using full lengths of metal fibres offers the best reinforcement.
- **Carbon / graphite fibre reinforced**-Carbon-graphite fibres are anisotropic & provide greatest reinforcement of denture base resins in terms of flexural strength & bending properties when placed longitudinally but because of difficulty encountered in placing the fibres centrally fibres are placed randomly oriented.
- **Aramid fibre reinforced**- Aramid fibre reinforcement increases the strength but again they are unesthetic & difficult to polish so limited to locations where aesthetics is not important
- **Polyethylene fibre reinforced**- Multi fibered polyethylene strands cut to 65 mm length & surface treated with epoxy-resin (to improve adhesion) are placed in resin during packing.
- **Highly drawn linear polyethylene fibres (HDLPF)-** Reinforcement done with 4 layers of fibres by pre preg technique. Between the two outer layers lies the main component of reinforcement efibers in horizontal plane along dental arch.
- **glass fibres** (have best aesthetics)- Six mm chopped glass fibers with 5% fiber in combination with injection moulding technique result in increase in transverse strength, elastic modulus& impact strength. Glass fibers may be modified by plasma polymerization technique using HEMA, EDA, TEGDME.
- **E-glass fibers**- Each strand of this E-glass is computer impregnated with a PMMA (porous polymer) and silane coupler that allows dissolution bonding to acrylic. (e.g. PreatPermaFiber)

2)**Hypoallergenic resins**- Diurethanedimethacrylate, Polyurethane, Polyethylenterephthalate and Polybutylenterephthalate. Hypoallergenic denture base materials exhibit significantly lower residual monomer content than PMMA, thus act as alternatives to Poly Methyl Methacrylate in allergic patients.

3) **Resins with modified chemical structure**- Addition of hydroxy-apatite fillers increases fracture toughness. Addition of Al2O3 fillers increases the flexural strength & thermal diffusivity that could lead to more patient satisfaction. 2% quaternary ammonium compound polymerised with a denture acrylic resin displays antiseptic properties & these dentures may be used for geriatric patients to improve their oral health. Addition of ceramic or sapphire whiskers to improve thermal diffusivity. Addition of 11-14% of several compounds of either bismuth or uranium or 35% of an organo-zirconium compound impart radiopacity equivalent to that of aluminium. Addition of Triphenyl Bismuth (Ph3Bi) is a promising new additive to provide radiopacity.

4) Thermoplastic resins- This new procedure, during which a fully polymerized basic material is softened by heat (without chemical changes) and injected afterwards, has opened up a new chapter in making dentures.It includes-Thermoplastic nylon, Thermoplastic acetal, Thermoplastic acrylic, Thermoplastic polycarbonate,PEEK.

5) **Enigma gum toning**-Custom shade matching of natural gingival tissue using 'Enigma' colour tones, Gives extra confidence to patient in appearance of their dentures, Available in Ivory, Light Pink, Natural Pink, Dark Pink & Light Brown. Different colors are mixed to get the desired gum tone.

6)**Valplast**- Valplast is a flexible denture base resin that is ideal for partial dentures and unilateral restorations. The resin is a biocompatible nylon thermoplastic with unique physical and aesthetic properties that provides unlimited design versatility and eliminates the concern about acrylic allergies.

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7)**Sunflex** -Sunflex Partial Dentures are made from a strong biocompatible nylon thermoplastic, and are unbreakable, yet lightweight and translucent which allows natural tissue to show through.

8**) Pro-flex-** Pro-flex denture material be indicated in some of the Anatomical considerations enables the material to effectively engage tooth and tissue undercuts. Also, Pro-flex is hypo-allergenic recommended for patients with known acrylic or metal sensitivities. Aesthetically the material is semi translucent, allowing the prosthetic to better blend with the colour of the natural gum tissue.

9) **Bio dent plast**- It is a semi-crystalline thermoplastic material with a linear structure characterized by high crystallinity. The material shows good physical and chemical properties such as increased hardness, tensile strength, and good dimensional stability. The material is opaque and prevents glare colour metal. Available shades A2, A3, B2, B3 (similar to vita shade).

10)**Acry Free**-Acry Free is an exclusive acrylic thermoplastic high impact resistance, for total and partial dentures by injection moulding system. Acry free is 10 times more resistant against breakage than conventional acrylics, light weight translucent and natural. Designed to high level of Aesthetic results, hypoallergenic and biocompatible, providing life-like dental appliances that virtually disappear in the mouth, since Acry free is injected into the flask, the final result is a very precise restoration., more retentive and more comfortable for the patient.

11) **Nature-acryl® mc-Microwave-Cured Denture Base Resin**

NATURE-CRYL MC is a denture acrylic resin specially created for microwave curing. This product assures that all high quality, precision dentures can be cured in just three minutes in a household microwave oven. Its unique plastic flask allows for more economical denture production. The product's computer-assisted shade matching assures aesthetically accurate upper and lower dentures, partial dentures, relines and repairs with all NATURE-CRYL system shades.

Dental Implants

Advances in surface treatments of dental implants-

1)**Biomimetic cap coatings**- Recent advances include fluoride phosphate substitution on the titanium dioxide surface, leading to localized calcium apatite deposition. A better cell response of dental implants can be achieved by the use of higher ratio of calcium and phosphorus along with the addition of silver nanoparticles into the oxide.

2) **Albumin**- Numerous studies have documented that the adsorption of bovine serum albumin (BSA) on titanium powder has beneficial effect on the release of calcium and phosphorus from the coating of the implant. It displays its effect by having not only osteoconductive but also osteo inductive property.

3)BISPHOSPHONATES (bps) - In osteoporosis the bisphosphonates like alendronate, pamidronate have shown promising results. Similar property of reduced bone turnover can be harnessed for better implant survival.

4)ANTIBIOTICS- antibiotic may be injected close to the site of implantation. Furthermore, co precipitation with biomimetic Ca-P coating can provide an opportunity to load higher amount of antibiotics. Addition of zinc and fluoride ions have shown to have improved efficacy in preventing infections.

5) Amelogenin- The amelogenin proteins form an important component of development of extracellular matrix and thus the enamel. Incorporation into the implant will augment the implant success rate.

6)Fluoride- The calcification of bone is influenced by fluoride. Studies have revealed the osteopromoting capacity of fluoride. Bone density and calcification of the bone have improved if fluoride is available during remodelling process of the bone when incorporated with dental implant. The rate of osteointegration and firm anchorage of the bone can be achieved with addition of fluoride.

7) Tetracycline-Tetracycline is known for its antimicrobial property. Also recent studies have highlighted its collagenase inhibiting property leading to increased cell proliferation and bone healing.

8) Discrete crystalline deposition (dcd)- In this process the calcium phosphate particles of size 20-100nm are deposited on the surface of implant. The implants are pre dual acid etched followed by deposition of calcium phosphate onto the implant surface by sol-gel process named Discrete Crystalline Deposition (DCD). Ultimately the incidence of infection is markedly reducing as there is reduced bacterial adhesion.

9) Photo functionalization- In this the dental implant is subjected to treatment with ultraviolet light. This treatment brings about a change in the titanium oxide resulting in enhanced osseointegration, and slows down age related degradations.

10)Extracellular matrix protein coating-The extracellular matrix provides crucial guidance for osteoprogenitor cells that migrate to the implant via interaction of integrins on the cell surface and RGD motifs of fibronectin. Upon the release of BMP,

these cells differentiate into osteoblasts. Studies done on use of extracellular matrix protein coating have shown to have a positive impact on peri-implant bone formation.

11) Peptide coating- The peptides are biomolecules composed of short sequences of amino acids. Their unique property facilitates osseointegration as well as inhibit bacterial overgrowth.

12) Bioactive glass coatings- The silica-based bioactive glasses have the property of are slowly resorbing synthetic osteoconductive materials. They form a strong chemical bond with the underlying bone. Studies by few authors have found implants with bioactive glass coating to have greater osseointegration as compared to non-coated implants.

Advances in dental implant materials

1) Poly-ether-ether-ketone (peek)- PEEK is a high performance semi-crystalline thermoplastic polymer. The advantage includes very good strength and stiffness with an outstanding thermal and chemical resistance—e.g., against oils and acids. Also, the colourless and elastic modules nature makes it resemblance to bone. However, the limiting factor being disturbed osteointegration.

2)Zirconia implants-Zirconia proved to be a superior material of choice as it was inert along with minimum ion release had higher fracture resilience and higher flexural strength. Due to its property of better osseointegration, minimal plaque accumulation and better maintenance of soft tissues and last but not the least aesthetic appeal has made it use widespread in implants.

•zirconia toughened alumina (zta) and alumina toughened zirconia (azt)- They are called either Zirconia toughened Alumina (ZTA) when Alumina is the main component (70–95 %), or Alumina Toughened Zirconia (ATZ), when Zirconia is the main component. The advantages include characteristics of Alumina (high hardness, high stiffness) with the mentioned properties of Zirconia, i.e., the high strength and high toughness, with improvement of slow crack growth resistance.

• Powder injection moulding (pim)- An alternative to classical machining for preparing Zirconia and other ceramics is the Powder injection moulding (PIM), also called ceramic injection moulding (CIM). It is a combination of injection moulding and powder technology mixing, injection moulding, debinding, and sintering. Various methods are available and depend on the pressure used for moulding and injection.

3)Tantalum implants- Tantalum with its success in orthopaedic implants has entered into the arena of dental implants. Its property of being corrosive resistant and better osseointegration has led to emergence of its use in the implants.

• Production of porous tantalum trabecular metal (pttm) -The porous tantalum trabecular metal as the name suggests has high volumetric porosity, high frictional characteristics and low modulus elasticity.

4) one-piece implants- Abutment and implant body are in one piece and not separate. They are commercially available in 3 mm diameter and 12, 15, and 18 mm length. (a) Maximum strength – It is one-piece, titanium alloy construction provides maximum strength, while its 3.0 mm diameter allows placement in areas of limited tooth-to-tooth spacing. (b) Minimal surgery – Because one-piece implants are placed using a single-stage protocol, the soft tissue experiences less trauma than typical two-stage protocols with maximum aesthetics.

5) Tapered implants & groovy implants- These implants offer in one body geometry, parallel walled with a diminishing thread depth toward the apical of the implant and secondary groove underneath each thread to enhance the initial stability. Cutting flutes incorporated at the apex of the implant give this implant design self-tapping capability. Dehiscence and fenestration are reduced.

6) LIGAPLANT- This technology is nothing but combination of the PDL cells with implant biomaterial. Currently research is going on in making this implant a noble one. Liga plants has certain properties like: 1. PDL cells act as a soft, richly vascular, and cellular connective tissue which permits forces elicited during masticatory function and other contact movements to be distributed to the alveolar process via alveolar bone proper. 2. It act as a, shock absorber giving the tooth some movement in the socket. 3. It provides Proprioception.

Maxillofacial Prosthetic Materials

1) **Silicone Block Co Polymers**- It has been found that silicone block copolymers are more tear-resistant than are conventional cross – linked silicone polymers. This is achieved by a surface modification consisting of the incorporation of block copolymers containing a PDMS block and a poly [2-(dimethylamino) ethyl methacrylate] (PDMAEMA) block in a PDMS matrix..

2)Polyphosphazenes- Polyphosphazenesfluoro elastomer has been developed for use as a resilient denture liner and has the potential to be used as a maxillofacial prosthetic material. Researchers in New Orleans dealt with maxillofacial prosthesis, have found that compounding polyphosphazenes with little or no fillers and decreasing the ratio of acrylic to rubber yields a softer rubber, with a HDA of 25, similar to human skin.

3) FoamingSilicones- Firtell et al. introduced foaming silicone for fabrication of light weight prosthesis. When silicon is mixed with stannous octoate catalyst, releases a gas in the vulcanization process as bubbles are released with the resulting silicone mass being increased and density being decreased, which presents a much lighter material.
4)Siphenylenes- Lewis and Castleberry described the potential use of Siphenylenes for facial prostheses. Siphenylenes are siloxane copolymers that contain methyl and phenyl groups. They are formulated as a pourable, viscous, room-temperature vulcanizing liquid.These polymers are transparent even when reinforced with silica fillers.
5)CAD-CAM- The manufacturing processes include subtractive manufacturing and additive manufacturing and should be selected in consideration of the material type, available technology, post-processing, accuracy, lead time, properties, and surface quality. Materials such as titanium, polyethylene, polyetheretherketone (PEEK), hydroxyapatite (HA), poly-DL-lactic acid (PDLLA), polylactide-co-glycolide acid (PLGA), and calcium phosphate are used.

2. Summary & Conclusion-Dentistry was merely an art practiced by barber-surgeons or artisans. With time, the knowledge of dentistry had spread mainly to all parts of world. With the advent in science and technology, dentistry came into hands of professionally minded dentists/ surgeons. Slowly and gradually dentists started orienting towards restoring and preservation of teeth. With the innovations and discoveries of new equipment, techniques, materials, and methods, dentistry continues to be enriched, refined, and grow towards a brighter future.There is no doubt that recent developments in dental materials have improved and will further advance dentistry and oral health care in the near future. Nevertheless, great challenges involving ethics and safety regulations, as well as cost-effectiveness, need to be addressed and overcome before new dental materials are introduced in the market. As the field of dentistry is dependent on the use of different materials, the use of advanced materials promises improved reliability and long-term efficiency because of their potential to execute specific functions intelligently in response to various local changes in the environment, thereby significantly improving the quality of dental treatment.Research in dental materials involved modification of existing materials or development of new and better materials for prosthetic applications. The goal of research has been to replace or restore lost or damaged tooth structure satisfying aesthetic and functional requirements. Hence it is important for dentists and patients to understand both the advantages and limitations of dental materials to allow the selection of the best dental material.

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