A COMPARATIVE EVALUATION OF FLUORIDE ION RELEASE AND ALAKALIZING PROPERTY OF A NEW BULKFILL COMPOSITE, GIOMER AND COMPOMER: AN IN-VITRO STUDY

DISSERTATION

Submitted to

BABU BANARASI DAS UNIVERSITY, LUCKNOW, UTTAR PRADESH

In the partial fulfilment of the requirement for the degree

of

MASTER OF DENTAL SURGERY

In the subject of

CONSERVATIVE DENTISTRY & ENDODONTICS

Submitted by

DR. PRACHI MISHRA

Under the guidance of

DR. VISHESH GUPTA

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

Batch: 2019-22 Enrollment No.: 1190322005

A COMPARATIVE EVALUATION OF FLUORIDE ION RELEASE AND ALAKALIZING PROPERTY OF A NEW BULKFILL COMPOSITE, GIOMER AND COMPOMER: AN *IN-VITRO* STUDY

DISSERTATION

Submitted to

BABU BANARASI DAS UNIVERSITY, LUCKNOW, UTTAR PRADESH

In the partial fulfilment of the requirement for the degree

of

MASTER OF DENTAL SURGERY

In the subject of

CONSERVATIVE DENTISTRY & ENDODONTICS

Submitted by

DR. PRACHI MISHRA

Under the guidance of

DR. VISHESH GUPTA

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES, LUCKNOW

Batch: 2019-22 **Enrollment No.: 1190322005**

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS
BABU BANARASI DAS COLLEGE OF DENTAL SCIENCE, LUCKNOW.

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"A COMPARATIVE EVALUATION OF FLUORIDE ION RELEASE AND ALAKALIZING PROPERTY OF A NEW BULKFILL COMPOSITE, GIOMER AND COMPOMER: AN *IN-VITRO* STUDY"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. Vishesh Gupta,** Reader, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date: 8th April 2022

Place: BBDCODS

Prachi M.

Signature of the Candidate

Dr. Prachi Mishra

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS
BABU BANARASI DAS COLLEGE OF DENTAL SCIENCE, LUCKNOW.

CERTIFICATE BY THE GUIDE / CO-GUIDE

This is to certify that the dissertation entitled "**A COMPARATIVE EVALUATION OF FLUORIDE ION RELEASE AND ALAKALIZING PROPERTY OF A NEW BULKFILL COMPOSITE, GIOMER AND COMPOMER: AN *IN-VITRO* STUDY**" is a bonafide work done by **Dr.Prachi Mishra**, under our direct supervision & guidance in partial fulfillment of the requirement for the degree of **Master of Dental Surgery (M.D.S.)** in the speciality of Conservative Dentistry and Endodontics.

Vishesh Gupta

GUIDE
Dr. Vishesh Gupta
Reader
Department of Conservative Dentistry and Endodontics,
Babu Banarasi Das College of Dental Sciences, Lucknow.

Tarun

CO-GUIDE
Dr. Tarun Saxena
Senior Lecturer
Department of Conservative Dentistry and Endodontics,
Babu Banarasi Das College of Dental Sciences, Lucknow.

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS
BABU BANARASI DAS COLLEGE OF DENTAL SCIENCE, LUCKNOW.

ENDORSEMENT BY THE HOD

This is to certify that this dissertation entitled **"A comparative evaluation of fluoride ion release and alkalizing property of a new bulkfill composite, giomer and compomer : An in-vitro study"** is a bonafide work done by **Dr. Prachi Mishra**, under the direct supervision & guidance of **Dr. Vishesh Gupta,** Reader, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Dr. B. Rajkumar
Professor & Head
Department of Conservative Dentistry and Endodontics,
Babu Banarasi Das College of Dental Sciences, Lucknow.

DEPARTMENT OF CONSERVATIVE DENTISTRY & ENDODONTICS
BABU BANARASI DAS COLLEGE OF DENTAL SCIENCE, LUCKNOW.

ENDORSEMENT BY THE HEAD OF THE INSTITUTE

This is to certify that this dissertation entitled **"A COMPARATIVE EVALUATION OF FLUORIDE ION RELEASE AND ALAKALIZING PROPERTY OF A NEW BULKFILL COMPOSITE, GIOMER AND COMPOMER: AN *IN-VITRO* STUDY"** is a bonafide work done by **Dr. Prachi Mishra**, under the direct supervision & guidance of **Dr. Vishesh Gupta,** Reader, Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University,Lucknow, Uttar Pradesh.

Dr. Puneet Ahuja
Principal
Babu Banarasi Das College of Dental Sciences,
Babu Banarasi Das University, Lucknow.

PRINCIPAL
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

COPYRIGHT

Date: 8th April 2022

Place: BBDCODS

Prachi M.

Signature of the Candidate

Dr. Prachi Mishra

INTRODUCTION

The continuous progress in field of restorative dentistry and technology has made possible the availability of various direct restorative materials to modern dental practice ranging from Dental amalgam to Glass Ionomer cement (GIC) and now novel composites. Of these, GIC differs for it's excellent property of release of fluoride ions, which helps in preventing enamel demineralization thereby promoting remineralization, reducing plaque growth and eventually helping to prevent dental caries.[1]

However, GIC lacks flexural strength and hence is not indicated for stress bearing areas.[2] To overcome this, new restorative materials have been introduced combining the properties of fluoride release and superior flexural strength.

"Cention N" is an "alkasite" restorative material which is one of it's type. Alkasite refers to a novel category of restorative material, which is similar to compomer or ormocer type of material and is essentially a subgroup of the composite restorative class.[3] This new category of restorative comprises of an alkaline filler, which is capable of releasing acid-neutralizing ions. It is radiopaque and releases fluoride, calcium and hydroxide ions and also exhibits high compressive and flexural strengths.[3]

Similarly, a new hybrid esthetic restorative material, Beautifil II, a Giomer, was introduced with physical properties and biocompatibility of composite resin and added benefits of high radiopacity, fluoride release, and antiplaque effect as that present in glass ionomer cement Beautifil II, is one of this type of Giomer.[4]

Also 'compomer', a polyacid modified composite resin was crafted, that is being sold as a filling material exhibiting the properties of glass ionomer cements and composites. An example of compomer being Dyract eXtra.

These recent restorative materials are indicated for posterior Class I and II restorations. They have the ability to release fluoride ions in the oral cavity when the pH drops. This property buffers the drop in pH in the mouth, preventing further caries favourable environment.

Thus, this in-vitro study has made a sincere attempt to evaluate and compare the fluoride ion release and alkalizing effect of three recent restorative materials viz Cention N, Beautifil II and Dyract eXtra.

Cention N is an “alkasite” restorative which is a novel category of filling material, like a compomer or ormocer type of restorative and is essentially a subgroup of the composite resin.[5] Cention N is a Urethane Dimethacrylate based, is self curing powder/liquid restorative with an optional/additional light-curing. The liquid comprises of dimethacrylates and initiators, whilst the powder contains various glass fillers, initiators and pigments. It is radio opaque and contains alkaline glass fillers capable of releasing fluoride, calcium and hydroxide ions. Due to the only use of cross-linking methacrylate monomers that combines with a stable, efficient self cure initiator, Cention N exhibits a high polymer network density and a higher degree of polymerization over the complete depth of the restoration.[6] It also includes special patented filler (Isofiller) which acts as a shrinkage stress reliever and due to its low elastic modulus this shrinkage stress reliever property within Cention N reduces polymerization shrinkage and microleakage.[7]

Compomer is a Polyacid-modified composite resin material that may contain either or both of the essential components of a glass ionomer cement but at levels insufficient to promote the acid-base cure reaction in the dark. In this class of materials the ingredients of a glass ionomer are present (acid decomposable glass and perhaps some polyacid) but not in sufficient amounts to promote setting.[8] With compomers, there is a single component system which cannot contain any water in order to prevent a premature glass ionomer reaction. The classification of compomers is more correctly termed Polyacrylic Acid Modified Composite Resins or PCMR’s**.**[8]

One new class of materials by the name of Giomers, aims to incorporate the best properties of composite resins and glass-ionomers: protection against carious lesion, good mechanical resistance and esthetics. Giomers represent one of the most recent developments in the field of fluoride releasing dental materials, combining esthetics with the possibility to have a finished surface and good mechanical resistance.[8]

Giomers have a conventional bis-GMA matrix and bioactive glass fillers. The setting reaction is light activated. The consistency is either flow or conventional; the amount of fluoride released is sufficient for antibacterial protection.[8] Working with giomers is considered easy in comparison to composite resins. They have high flexibility and are less likely to be dislocated from areas with high functional stress. Colour, fluorescence (property to absorb light and spontaneously emit a higher wavelength, bringing vitality to a restoration) and translucency (property that allows the passage of light), together, essentially contribute to the esthetical integration of a new restoration. Therefore, new materials should imitate the color of natural teeth and all other optical properties.[9]

There is no ideal formula for a dental material that is applicable to all clinical cases.[9] Bioactive glass included in the composition of giomers, dissolves upon contact with biological fluids, allowing for a therapeutic ion release like phosphate, fluoride, calcium, influencing the capacity to form apatite. This approach is a rather new one for the dentistry field.[9]

AIMS AND OBJECTIVES

AIM: The study is being conducted to evaluate and compare fluoride ion release and alkalizing effect by Bulkfill composite (Cention-N), Giomer (Shofu Beautifil II) and Compomer (Dyract eXtra)

OBJECTIVES:

1. To evaluate fluoride ion release and alkalizing effect of alkasite restorative material, Cention-N in neutral and acidic pH solution.

2. To evaluate fluoride ion release and alkalizing effect of giomer, Shofu Beautifil II in neutral and acidic pH solution.

3. To evaluate fluoride ion release and alkalizing effect of compomer, Dyract eXtra in neutral and acidic pH solution.

4. Intergroup comparison of the experimental restorative materials for fluoride ion release and alkalizing effect.

5. To conclude which material has the best alkalizing and fluoride ion releasing property.

REVIEW OF LITERATURE

1. **Mallakh B.F El, Sarkar NK (1990)** evaluated in vitro, the fluoride release from glass-ionomer cements in de-ionized water and artificial saliva. The materials used in this study included Ketac-Fil (ESPE), Ketac-Silver (ESPE), Fuji-II (GC), and Miracle Mix (GC) The results showed that: (1) glass-ionomer cements released more fluoride in de-ionized water than in artificial saliva; (2) Ketac-Fil released 20% more fluoride in saliva than did Fuji-II, the latter releasing 49% more fluoride than Ketac-Fil in de-ionized water; and (3) conventional glass ionomers released more fluoride than did metal-reinforced ones in both media. [10]
2. **Forsten L (1990)** conducted an in vitro study comparing the short and long-term fluoride release from glass ionomers and other fluoride-containing filling materials, one amalgam and one composite. It was found that the fluoride release from the glass ionomers decreased with time and a constant level was reached for mos.t products during the 2-yr period. The release was increased by lowering the pH of the storage solution. The release from the glass ionomers was clearly greater than from the amalgam and the composite. [11]
3. **S.L Creanor, L.M.C. Carruthers, W.P Saunders, Strang R, Foye RH (1994)** investigated in vitro, the fluoride releasising characteristic of five glass ionomer cements available namely: Ketac Fil, Chemfil Superior, Fuji II LC, Aquacem and Vitrebond. This study showed that all five glass ionomer cements take up as well as release fluoride and that the amount of fluoride released may be profound clinical significance.[12]
4. **Silvana M. Berlacchini, Pablo R Abale, Adriana Blank, Maria R Baglieto, Ricardo L. Macclii (1999)** compared the degree of solubility and the fluoride release of glass-ionomer cements and "compomers" as a function of time. Components of both the ionomers and compomers that were studied can dissolve in water. The materials used in this study included Conventional ionomers, Fuji IX (GC), VivaGlass Fil (Vivadent), Vivaglass Cem, Resin modified ionomers, Advance (Dentsply), Fuji Duet (GC), Vitremer Luting (3M),

Compomers, Compoglass Vivadent, Dyract Cem Dentsply. The materials leak fluoride ions in amounts that differ according to the characteristics of the individual products.[13]

5. **John W. Nicholson, Angela Aggarwal, Beata Czarnecka, Honorata Limanowska (1999)** studied the rate of change of pH of aqueous lactic acid at pH 4.2-4.5 (i.e. a little below that of active caries in vivo) in contact with disks of various commercial glass-ionomer cements in two configurations. The extent and speed of the change in pH led to the conclusion that ability of glass-ionomers to increase pH is likely to be an important mechanism of caries protection under clinical conditions. [14]
6. **H K Yip , R J Smales (2000)**, compared the fluoride ion release from a freshly mixed polyacid-modified resin composite, or "compomer" (Dyract), and 3 resin-modified glass-ionomer cements (Fuji II LC, Photac-Fil, and Vitremer). Fluoride measurements were carried out using a fluoride ion-selective electrode connected to a pH ion-selective electrode meter. Fuji II LC, Photac-Fil, and Vitremer showed high initial release values, which decreased exponentially and then showed a slow decline during the ensuing time. The amounts of fluoride ion release measured at any time interval varied with the units of measurement chosen, but the pattern of release remained the same. [15]
7. **G. Vermeersch, G. Leloup and J. Vreven (2001)** measured in vitro the short and long-term fluoride release of 16 products (seven conventional glass–ionomers, release of the materials by their type (conventional five light-activated glass–ionomers, two polyacid- or resin-modified glass–ionomers, polyacid modified resin composites and two resin modified resin composite and resin composite) commercialized as fluoride-releasing materials. The materials used in this study included Ketac Fil, HiDense, HiFi, Vitrebond, Photac Fil, Fuji II, Vivaglass, Fuji II, Fuji IX, Vitremer, Ketac Molar, Fuji II, Compoglass, Dyract, HelioMolar, Tetric. The link between fluoride release and an acid base reaction was confirmed in this study. [16]

8. **Marie Helvatjoglu Antoniades, Panagiotis Karantakis, Yannis Papadogiannis,, Hryssostomos Kapetanios (2001)** conducted an in vitro study that evaluated and compared fluoride release in distilled water from different types of restorative materials Miracle-Mix, Fuji ionomer type III, Fuji II LC improved, and Ketac-Silver), a luting cement (Ketac Cem), a compomer (Compoglass Flow), 2 sealants (Fissurit F, Helioseal F), and a composite resin (Tetric) was evaluated at time intervals of 4, 8, 12, and 24 hours and 2, 3, 7, 14, 28, 56, and 112 days. Fluoride was released from all the evaluated materials, with considerable variation in the rate of release but a similar pattern. It was concluded that the glass ionomer formulations and the compomer released more fluoride than the sealants and the composite resin tested.[17]
9. **Y Chacko , L Lakshminarayanan (2001)** in an in vivo study evaluated, the pH stabilizing properties of a posterior resin composite (Ariston pHc, Vivadent Ets, Schaan/Liechtenstein). The results showed that the resin composite countered the acidic pH of saliva and maintained it at levels where demineralization would not occur.[18]
10. **Keiji Kawai , Teruyuki Takaoka (2002)** quantitatively measured the amount of fluoride, hydroxy ion and hydroxyethyl methacrylate (HEMA) released from various light-cured restorative materials. The materials tested were three resin-modified glass-ionomer cements (RMGI): Photac-Fil Aplicap, Vitremer, and Fuji II LC and two polyacid-modified resin-based composites (compomer): Dyract and Variglass VLC. The RMGIs released the greater amount of fluoride and smaller amounts of HEMA compared to the compomers at both the 8- and 24-hour eluates.[19]
11. **Jan W. V., Van Dijken (2002)** conducted an in vivo study evaluating the durability of a new resin composite that releases calcium-, fluoride- and hydroxyl ions at low pH. It was concluded that the new ion-releasing resin composite showed, despite promising pH stabilizing properties, a clinically unacceptable failure rate.[20]

12. **Adrian U J Yap, S Y Tham, L Y Zhu, H K Lee (2002)** , studied in vitro, the short-term fluoride release of a giomer (Reactmer), a compomer (Dyract AP), a conventional glass ionomer cement (Fuji II Cap) and a resin-modified glass ionomer cement (Fuji II LC). The glass ionomers released significantly more fluoride than the compomer and giomer at day one. Although fluoride release of the giomer was significantly greater than the other materials at day seven whereas it became significantly lower at day 28.[21]
13. **C.M. Carey, M. Spencer, R.J. Gove, and F.C. Eichmiller (2003)** evaluated the effect of pH on the rate of fluoride ion release from a resin modified glass ionomer cement (KetacFil). The results showed that the release rate began with a fast burst of fluoride which quickly diminished to low levels in 3 days. Under neutral pH conditions, the rate of fluoride release at 72 hrs was significantly slower than at pH 4.[22]
14. **P Passi, A Zadro, S Varotto, M Berengo, D Haessler (2004)** evaluated in vitro, the pH variations induced by Ariston pHc and 2 other composite resins (P60 and Z100). The results strongly suggested that none of the 3 tested materials could achieve an effective buffering action in vitro on low salivary pH values. However, the ability of Ariston pHc to raise the pH in distilled water, and to a lesser degree in acidified saliva, suggested that an in vivo buffering effect was evident.[23]
15. **J. W. Nicholson, B. Czarcnecka (2004)** studied in vitro, three commercial compomers viz Dyract AP, Compoglass F and F2000, for their interaction with aqueous solutions (i.e. water at pH 5-9 and lactic acid at pH 2-7) mass changes, pH changes and ion-release were determined. All three cured compomers absorbed water and altered the pH of the solutions, though this was statistically significant only in lactic acid. They were found to release Na, Ca, Sr, Al, Si, P and F ions, with greater amounts being released in acidic conditions than neutral ones.[24]

16. **Toshiyuki Itota, Thomas E.Carrick, Masahiro Yoshiyama, F.McCabe John (2004)** examined in an in vitro study examined the fluoride recharging and releasing abilities of resin-based materials containing fluoridated glass filler to determine whether the extent of the glass–ionomer matrix of the material affects these properties. Reactmer paste, Dyract AP and Xeno CF, were used for this study. The results suggested that the extent of the glass–ionomer matrix of the glass filler played an important role for fluoride-releasing and recharging abilities of the resin-based materials.[25]
17. **A. Perssona P. Lingströmb J.W.V. van Dijkena (2005)** conducted an in vivo study to evaluate the neutralizing capacity, registered as change of plaque acidogenicity, on aged proximal restorations of an ion-releasing composite resin (IRCR), which releases hydroxyl, calcium, and fluoride ions at low pH. They concluded that IRCR restorations countered the plaque pH fall and maintained it at levels where less enamel and dentin demineralization can occur.[26]
18. **Delbem AC, Pedrini D, França JG, Machado TM (2005)** examined in vitro, the differences in fluoride release and recharge among four restorative materials Vitremer, Ketac-Fil, Fuji II LC and Freedom following treatment with APF or neutral fluoride gel for one or four minutes. The fluoride release was measured for 15 days. It was concluded that RM-GICs were the most effective materials with regards to fluoride release after application of APF gel for four minutes.[27]
19. **Mousavinasab Mostafa Sayed, Meyers Ian (2009)** conducted in an in vitro study and examined the amounts of fluoride released from fluoride-containing materials, four glass ionomer cements (Fuji IX, Fuji VII, Fuji IX Extra and Fuji II LC), a compomer (Dyract Extra) and a giomer (Beautifil). The results showed that Fuji IX, Fuji VII, Fuji IX Extra, and Fuji II LC released higher amounts of fluoride compared to Beautifil and Dyract Extra.[28]

20. **Anupama Kiran, Vani Hegde (2010)** conducted an in vitro study that evaluated and compared the amount and pattern of fluoride release from three types of glass ionomer cements GC Fuji II, GC Fuji VII and GC Fuji IX in water (pH 7) and lactic acid (pH 5.2) for a period of 28 days at five intervals. The results showed that the amount of fluoride released by GC Fuji VII was statistically highly significant on 1st and 7th day when compared to GC Fuji II and GC Fuji IX. PH of the environment affected the amount of fluoride released, the amount of fluoride release in lactic acid was considerably greater than in deionised water.[29]

21. **P Neelakantan , S John , S Anand N Sureshbabu. C Subbarao (2011)** evaluated the amount and pattern of fluoride release from a new glass-ionomer-based material (nano-ionomer) with other restorative materials and correlated the surface area to volume of nano-sized filler with its capacity to release fluoride in the powder, more quickly increasing the fluoride. The materials evaluated were a nano-ionomer (Ketac N 100), a conventional glass-ionomer cement (GC Fuji II), a resin-modified glass ionomer cement (GC Fuji II LC), a compomer (Dyract F) and a fluoride-releasing resin composite (Tetric N Flow). A resin composite (Synergy Flow) served as the control. A low constant level of fluoride release was seen from the compomer and fluoride-releasing resin composite throughout the study period.[30]

22. **Moreau JL, Xu HH (2011)** investigated in vitro the effects of solution pH and immersion time on the mechanical properties and Fluoride release of restorative materials. Three resin-modified glass ionomers (Viremer, Fuji II LC, Ketac Nano), one compomer (Dyract Flow), and one composite (Heliomolar), were tested. The restoratives tested were able to greatly increase the F release at acidic, cariogenic pH, when these ions are most needed to inhibit caries.[31]

23. **Jingarwar MM, Pathak A, Bajwa NK, Sidhu HS (2014)** studied in vitro, the fluoride release and recharge ability of restorative materials like GC2, Ketac N100 and Beautifil II in deionised water, artificial saliva and lactic acid. Pellets were prepared from GC2, Ketac N100 and Beautifil II. Fluoride release found was more after 24 h for all materials tested in all media then decrease gradually. GC2 showed more fluoride release than Ketac N100 at 24 hours and on 7(th) day but onwards Ketac N100 released significantly more fluoride. Beautifil II showed least fluoride release at all measured intervals in all media. Order of fluoride release in media was lactic acid > deionised water > artificial saliva for all tested materials.[32]

24. **Markus Fuss, Michael J Wicht, Thomas Attin, Sonja H M Derman, Michael J Noack (2017)** investigated the buffering capacity of restorative materials during a simulated

    carious and intrinsic erosive attack. Cavities with a volume of 130 μl were milled (Cerec MC XL) out of blocks of Ceram X Mono (CM), Quixfil (QX), Filtek Supreme (FS), Apa Fill 3 (AF), an experimental dual-curing composite containing a bioactive glass (EX), Dyract eXtra (DY), Beautifil (BE), Equia Fil (EQ), Telio CAD (TL) (negative control), TheraCal (TC; positive control), and extracted teeth (ED). 80 μl of lactic acid (pH 4.5) and hydrochloric acid (pH 2.6) were each pipetted into the cavities of two samples of each material Conventi

    onal restorative materials do not buffer better than human teeth. However, the experimental composite demonstrates that buffering against carious and intrinsic erosive acid attacks is technically feasible.[33]

25. **Gupta Nupur, Jaiswal Shikha, Nikhil Vineeta, Gupta Sachin, Jha Padmanabh, Bansal Parul (2019)** conducted an in vitro study to evaluate and compare fluoride ion release and alkalising potential by Cention-N and conventional glass-ionomer cement

(GIC). It was observed that Cention-N had the highest fluoride ion release and alkalizing potential as compared to GIC.[1]

26. **Alicja Porenczuk, Bartłomiej Jankiewicz, Magdalena Naurecka, Bartosz Bartosewicz et al, (2019)**, in an in vitro study compared the fluoride ion release profiles from a bioglass-reinforced RMGIC, a conventional glass-ionomer cement (GIC) and a nanohybrid restorative polymer resin. The quantity of fluoride ions released from ACTIVA, Ketac Molar Quick Aplicap and Tetric EvoCeram was assessed using a fluoride-specific electrode. The fluoride ion release profile of ACTIVA was lower than the GIC Keta Molar Quick Aplicap, but significantly higher than the nanohybrid restorative polymer resin Tetric EvoCeram.[34]

27. **Katarina Kelić, Matej Par, Kristina Peroš, Ivana Šutej, Zrinka Tarle (2020),** determined in vitro, the effect of two adhesive systems and a glass ionomer coating resin on fluoride release and concurrent pH changes over a period of 168 days. The restorative materials investigated were a giomer (Beautiful II), an "alkasite" material (Cention), a conventional composite (Filtek Z250), and a glass ionomer cement (Fuji IX Extra). Light-cured composite specimens were coated using G-aenial Bond and Clearfil Universal Bond Quick. Glass ionomer specimens were coated using GC Fuji Coat LC. The composites coated with G-aenial Bond showed pH values in the acidic range (4.4-5.7) after 1 h and 24 h. Fluoride release varied among the investigated restorative materials and depended on the use of dental adhesives and coatings. The pH of all materials, coating types and time points varied.[35]

28. **Shwetha Balagopal, Sridhar Nekkanti, Kanwardeep Kaur (2020),** in an in vitro study examined and compared the flexural strength, shear bond strength, and fluoride-releasing ability of glass ionomer cement (GIC), Fuji IX GIC, and a new alkasite filling material, Cention N. Fluoride release of Fuji IX GIC was significantly higher compared to

that of control Cention N over a period of 21 days. Flexural strength of Cention N was significantly higher compared to Fuji IX GIC and there were no significant differences in shear bond strength of both the materials.[36]

29. **Shahin Kasraei, Sahebeh Haghi, Sara Valizadeh ,Narges Panahandeh, Sogol Nejadkarimi (2021)**, compared the phosphate ion release and alkalizing potential of three bioactive materials in comparison with composite resin. The materials used in this study included Fuji II LC resin modified glass ionomer (RMGI), Activa BioActive, Cention N, and Z250 composite. Phosphate ion release was quantified by a spectrophotometer while the pH value was measured by a pH meter. All materials, except for Z250, increased the pH of the environment. Fuji II LC had maximum alkalizing effect at all time points followed by Cention N and Activa BioActive.[37]

30. **Anna Lehmann, Kacper Nijakowski , Michalina Nowakowska , Patryk Wo´s , Maria Misiaszek, Anna Surdacka (2021)** assessed in vitro, how selected restorative materials influence the environmental pH. A total of 150 specimens (30 in eachof 5 groups like Ketac Molar, Riva LC, Riva SC, Filtek Bulk Fill, and Evetric) were placed in 100 sterile hermetic polyethene containers with saline and stored in 37 ◦C. The highest final pH was obtained with Ketac Molar at about 5.9. Double samples had lower pH values than single samples, irrespective of the type of material.[38]

MATERIALS AND METHODOLOGY

The present in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Babu Banarasi Das College of Dental Sciences, Lucknow in Collaboration with, Cytogene Research and Development Laboratory, Lucknow.

A total of 45 human permanent mandibular molars were collected following the inclusion and exclusion criteria.

The following inclusion & exclusion criteria were set to select the teeth:

Inclusion criteria:

1. Non carious, sound and intact human mandibular molars with normal morphology

Exclusion Criteria:

1. Teeth with any crack or caries.
2. Teeth with developmental anomaly.
3. Teeth with any restorations
4. Teeth with any resorptive defects

The collected teeth were cleaned using ultrasonic scaler and then stored in 0.9% normal saline until further use.

Materials and Equipments Used in the study: (Fig. 1)

1. Ultrasonic scaler (Biosonic, Germany)
2. Periodontal curette (#1235/2-3) (API, Germany)
3. Normal saline (0.9%) (Swaroop, India)
4. Straight hand piece (NSK , Japan)
5. Diamond disc (0.15mm) and a flat cylindrical diamond bur (Shofu, Japan)
6. Micro motor (Unicorn Denmart, India)

7. Airotor (NSK, Japan)
8. Nail varnish (Lakme´, India)
9. Applicator tip (Fine) (Oro, India)
10. Curing Light (Woodpecker, China)
11. Composite filling instruments (GDC, Hoshiyarpur)
12. Deionized water (Ultra Gold, India)
13. Lactic acid (BRM, India)
14. Plastic containers (Sunpet, India)
15. Incubator (Genetix, India)
16. Fluoride meter (ExStik II, India)
17. Digital pH meter (AviMake, India)

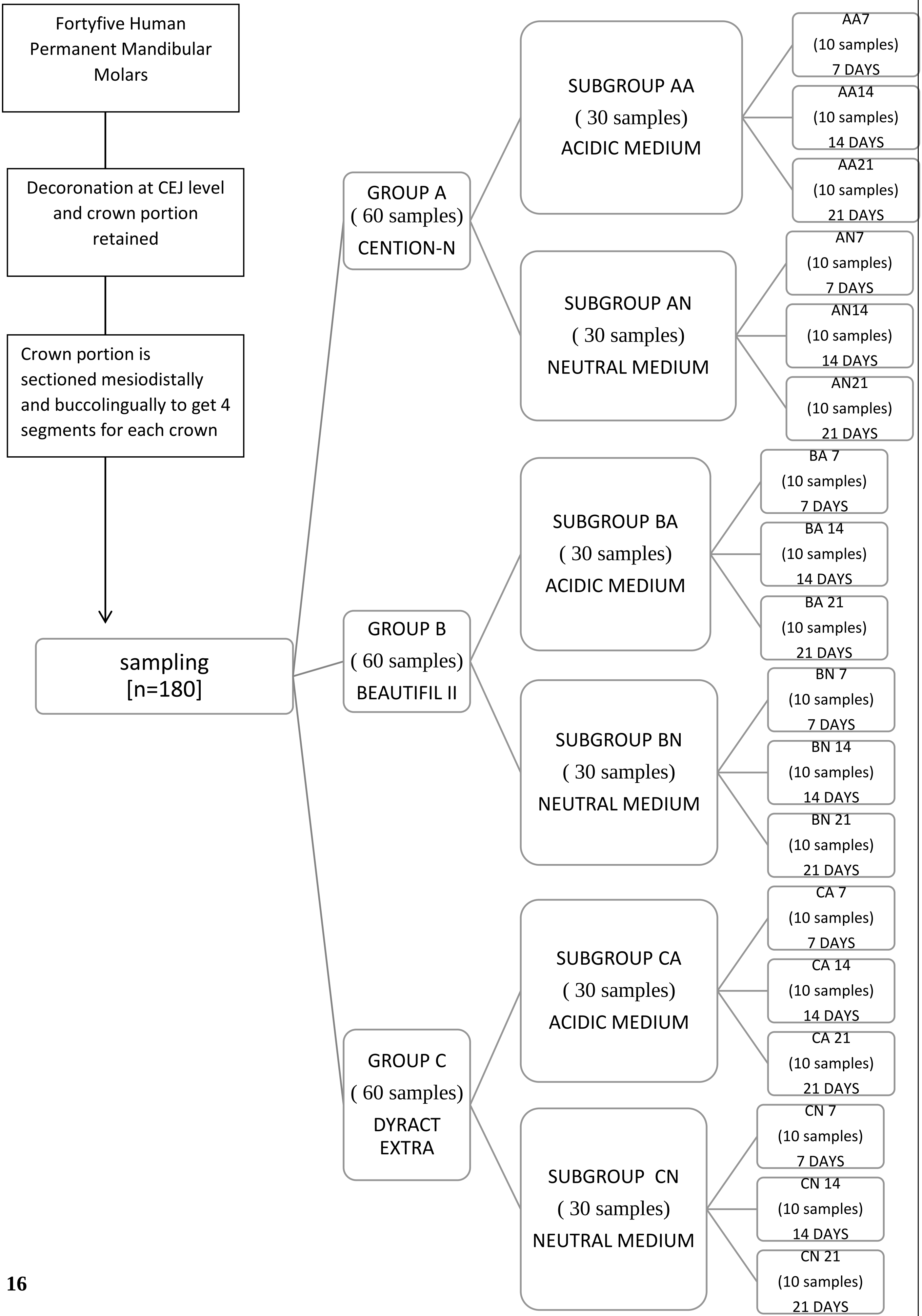
For Restoration: (Fig. 2)

1. Cention-N (Ivoclar, Lichtenstein) (LOT Number : #684199; Exp : 2023-05-17)
2. Beautifil II (Shofu, Japan) (LOT Number : #PN1408 ; Exp : 2023-09-30)
3. Dyract eXtra (Dentsply, Sirona) (LOT Number : #2101000120 ; Exp : 222-12-31)

Study subjects: (Fig. 3,4)

Forty five freshly extracted permanent human mandibular molars extracted due to periodontal reasons were selected as per inclusion and exclusion criteria.

Study Sample And Size:



Sampling :

Total forty five number of freshly extracted human permanent mandibular molars were collected as per inclusion and exclusion criteria (Fig. 3A, Plate II).

Each of the sample was then sectioned from the CEJ level and the root piece was discarded (Fig. 3D, Plate II).

Further, each crown portion was sectioned into four parts mesiodistally and buccolingually (Fig. 3E, Plate II).

Thus, a total of 180 samples were obtained (Fig. 3F, Plate II).

These samples (n=180) were divided in 3 groups with each group containing 60 samples.

Group A-60

Group B-60

Group C-60

Methodology:

Specimen Preparation:

Forty five human permanent mandibular molar teeth were freshly extracted due to periodontal/orthodontic reasons. They were selected after fulfilling the inclusion and exclusion criteria . The samples were cleaned using Biosonic ultrasonic scaler and the cleaned samples were then stored in normal saline till further use (Fig. 2, Plate II).. All the teeth were decoronated at the level of the cementoenamel junction and the root portion was removed. (Fig. 3D, Plate II). Each sample was then further sectioned mesiodistally as well as buccolingually in four equal segments to obtain total 180 sample size. (Fig. 3E, Plate II).

Further, a flat-end cylindrical diamond point was used at a speed of 300,000 rpm under continuous air water to prepare the standardized cavities with a depth and width of 2 mm. (Fig. 5A, Plate IV).

These 180 sample segments were randomly divided into the following three equal groups which are as follows:

Group A (Cention-N)- 60 samples

Group B (Beautifil II)- 60 samples

Group C (Dyract eXtra)- 60 samples

The cavities in all the groups were restored using Teflon coated composite instruments with the respective restorative materials to be tested. The materials were filled according to the manufacturer’s instructions. Further, two layers of nail varnish were used to coat the samples, leaving a margin of 1 mm around the restoration.

These restored 60 samples group was subdivided into two equal subgroups, comprising of 30 samples on the basis of pH (acidic pH–4, neutral pH–6.8) of the solution to be used for testing. The subgroups representing acidic pH were labelled as AA, BA, and CA and subgroups representing neutral pH were labelled as AN, BN and CN respectively.

Finally, each of these subgroups were further divided into three subgroups on the basis of duration (7 days, 14 days, and 21 days) for which testing was done.

One-hundred and eighty plastic containers were prepared each containing 5 ml of deionized water/acidic medium. Ten samples from each of the subgroup were stored in each of these plastic containers. After 24 hours, the containers were thoroughly shaken, samples were then removed and were then reimmersed in the plastic container-containing fresh 5 mL of deionized water. For the acidic medium, Lactic acid solution was used to achieve a ph of 4 in deionised water. The concerned samples were then immersed in 5 mL of acidic medium. The same procedure was repeated for 7 days for subgroups –AN7, BN 7, CN 7, AA 7, BA 7, and CA 7, for 14 days for subgroups –AN14, BN 14, CN 14 and AA 14, BA 14, and CA 14, and for 21 days for subgroups –AN 21, BN 21, CN 21 and AA21, BA 21, and CA 21.

Analysis of the Samples:

The cumulative fluoride ion release and change in pH was assessed at the end of 7 days, 14 days, and 21 days utilizing fluoride meter and pH meter, respectively. The observations thus obtained were then statistically analysed using ANOVA-F, Paired "t", and Unpaired t-test.

ANOVA Analysis of Variance:

Analysis of variance (ANOVA) is an analysis tool used in statistics that splits an observed aggregate variability found inside a data set into two parts: systematic factors and random factors. The systematic factors have a statistical influence on the given data set, while the random factors do not. Analysts use the ANOVA test to determine the influence that independent variables have on the dependent variable in a regression study.

The Formula for ANOVA is:

F=MST/MSE

F=ANOVA coefficient

MST=Mean sum of squares due to treatment

MSE=Mean sum of squares due to error

<u>Paired t-test:</u>

A paired samples t-test is used to compare the means of two samples when each observation in one sample can be paired with an observation in the other sample.

A paired samples t-test always uses the following null hypothesis:

- **H_0:** $\mu_1 = \mu_2$ (the two population means are equal)

The alternative hypothesis can be either two-tailed, left-tailed, or right-tailed:

- **H_1 (two-tailed):** $\mu_1 \neq \mu_2$ (the two population means are not equal)
- **H_1 (left-tailed):** $\mu_1 < \mu_2$ (population 1 mean is less than population 2 mean)
- **H_1 (right-tailed):** $\mu_1 > \mu_2$ (population 1 mean is greater than population 2 mean)

We use the following formula to calculate the test statistic t:

$$t = x_{diff} / (s_{diff}/\sqrt{n})$$

where:

- **x_{diff}:** sample mean of the differences
- **s:** sample standard deviation of the differences
- **n:** sample size (i.e. number of pairs)

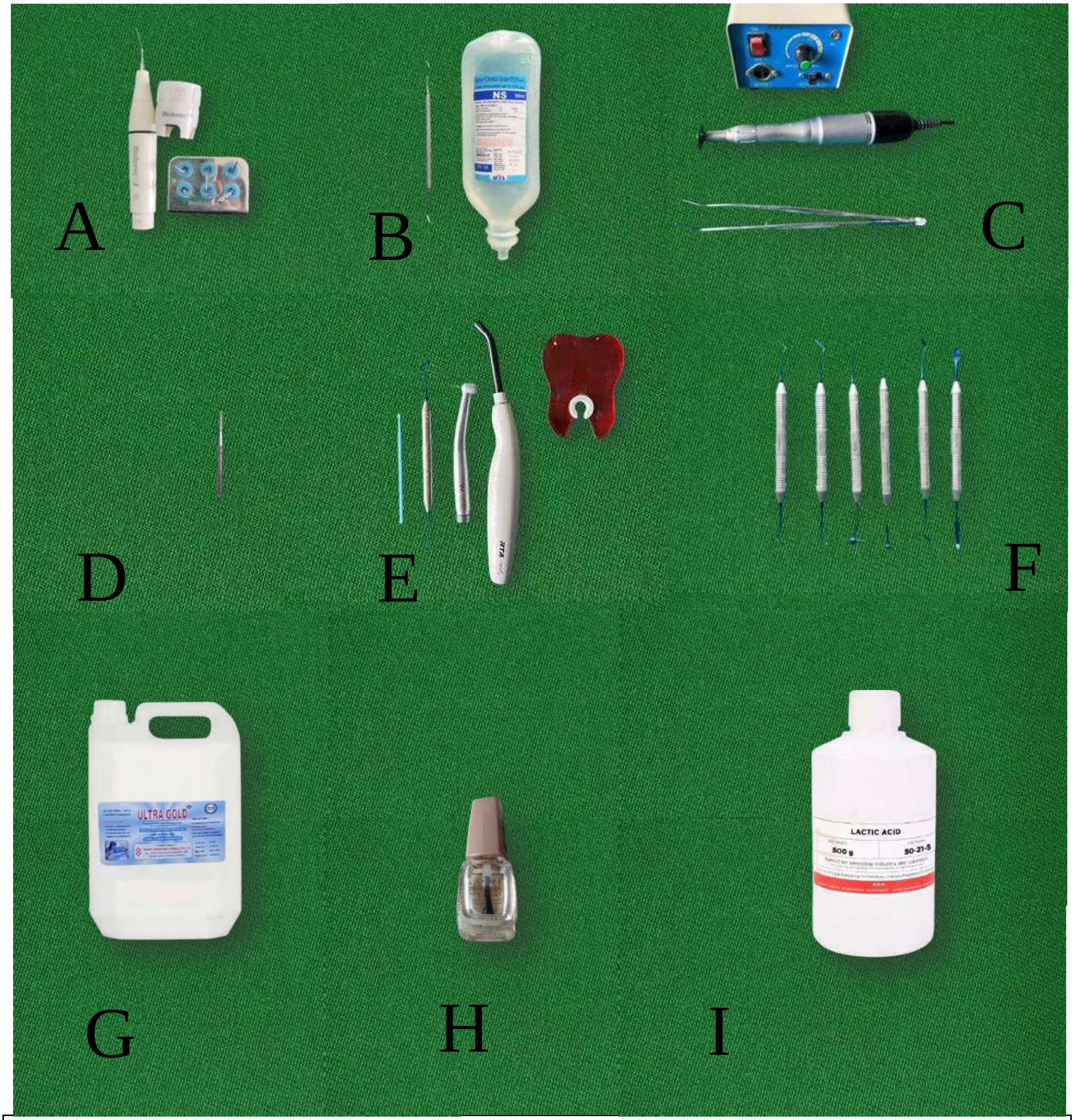


Fig. 1A: Biosonic ultrasonic scaler with tips B: Periodontal curette #1235/2-3 and normal saline C: Tweezer, Micromotor straight handpiece attached with diamond disc (0.15mm) with control box D: Long flat cylindrical diamond point E: Fine applicator tip, composite filling instrument, airotor, curing light F: Composite filling instruments G: Deionised water H: Nail varnish I: Lactic acid

PLATE I

Fig.2: Extracted human permanent mandibular molars stored in normal saline

Fig. 3A: Human extracted molars used in the study

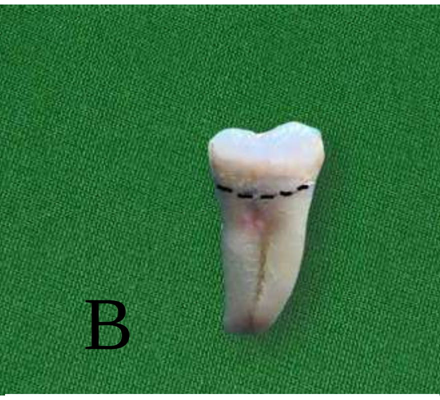


Fig. 3B: Markings made for decoronation of sample

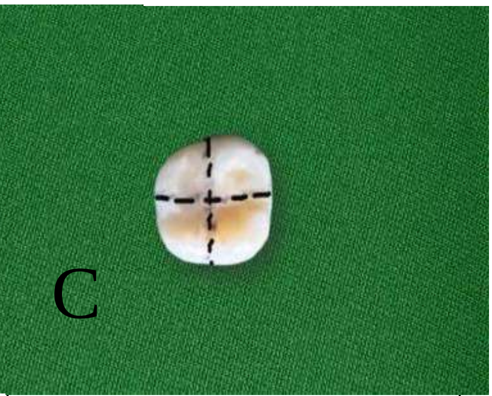


Fig.3C: Markings made for sectioning the crown mesiodistally and buccolingually

Fig.3D: Sectioning of the tooth.

Fig. 3E: Sectioned samples obtained.

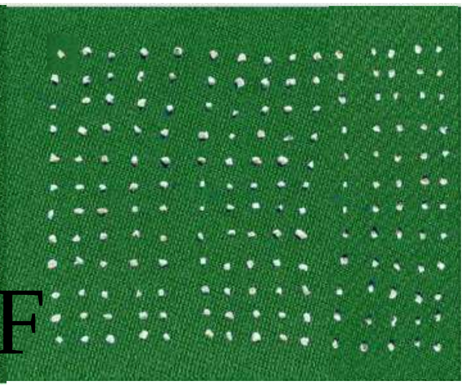


Fig.3F: 180 samples obtained.

PLATE II

Fig. 4A: Cention N used for restoring Group A samples.

Fig. 4B: Beautifil II used for restoring Group B samples.

Fig. 4C: Dyract eXtra used for restoring Group C samples.

PLATE III

Fig. 5A: Preparation of cavity on sample

Fig. 5B: Prepared cavity on sample

PLATE IV

Fig. 6A: Group A (Cention N) dispensed for restoring the prepared cavities.

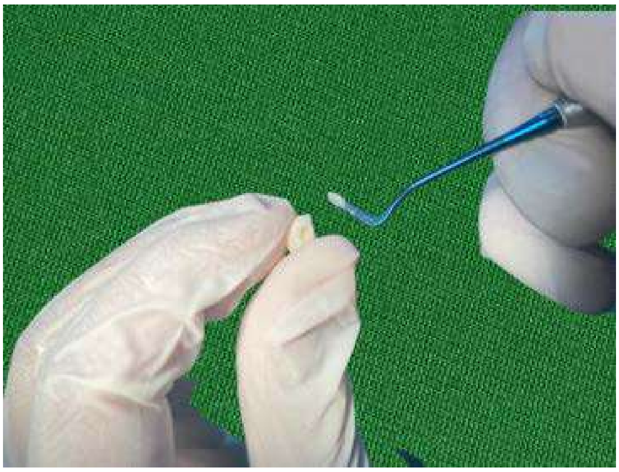


Fig. 6B: Group A (Cention N) being restored in the prepared cavity.

Fig. 6C: Curing of the material

PLATE V

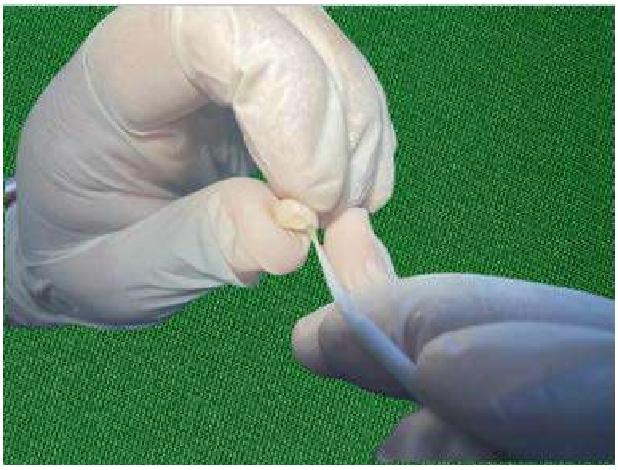


Fig. 6D: Application of Nail varnish.

Fig. 6E: Final group A (Cention N) sample obtained after restoration

Fig. 6F: Sample stored in the respective medium (deionized water & acidic medium)

PLATE VI

Fig. 7A: Group B material (Beautifil II) being carried for restoration of prepared cavities.

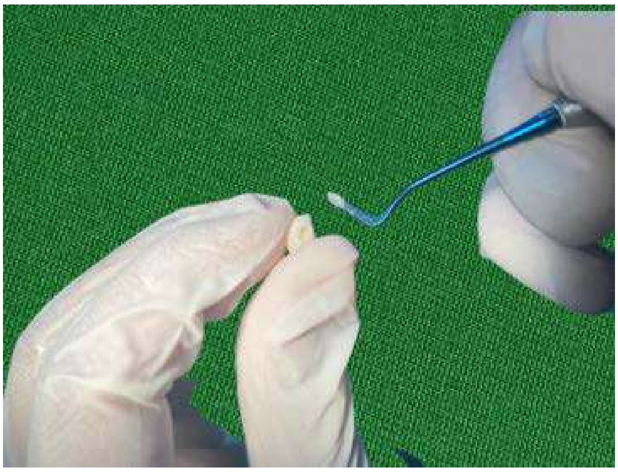


Fig. 7B: Group B (Beautifil II) being restored in the prepared cavity.

Fig. 7C: Curing of the material

PLATE VII

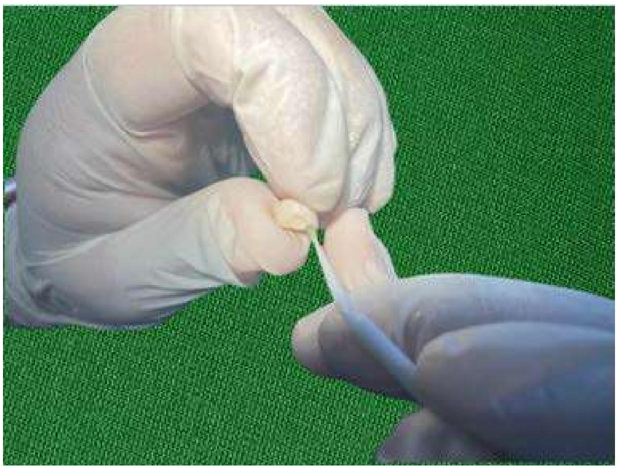


Fig. 7D: Application of Nail varnish.

Fig. 7E: Final group B (Beautifil II) sample obtained after restoration

Fig. 7F: Sample stored in the respective medium (deionized water & acidic medium)

PLATE VIII

Fig. 8A: Group C material (Dyract eXtra) manipulation for restoration of samples

Fig. 8B: Group C (Dyract eXtra) being restored in the prepared cavity.

Fig. 8C: Curing of the material

PLATE IX

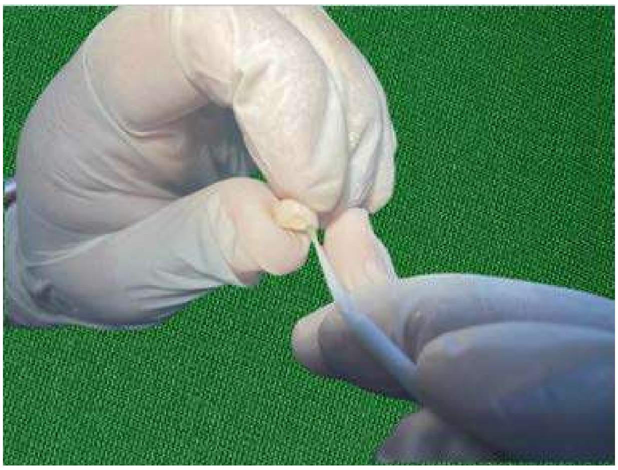


Fig. 8D: Application of Nail varnish.

Fig. 8E: Final sample group C (Dyract eXtra) obtained after restoration

Fig. 8F: Sample stored in the respective medium (deionized water & acidic medium)

PLATE X

Fig. 9: Incubator

Fig. 10: Digital pH meter

Fig. 11: Fluoride meter

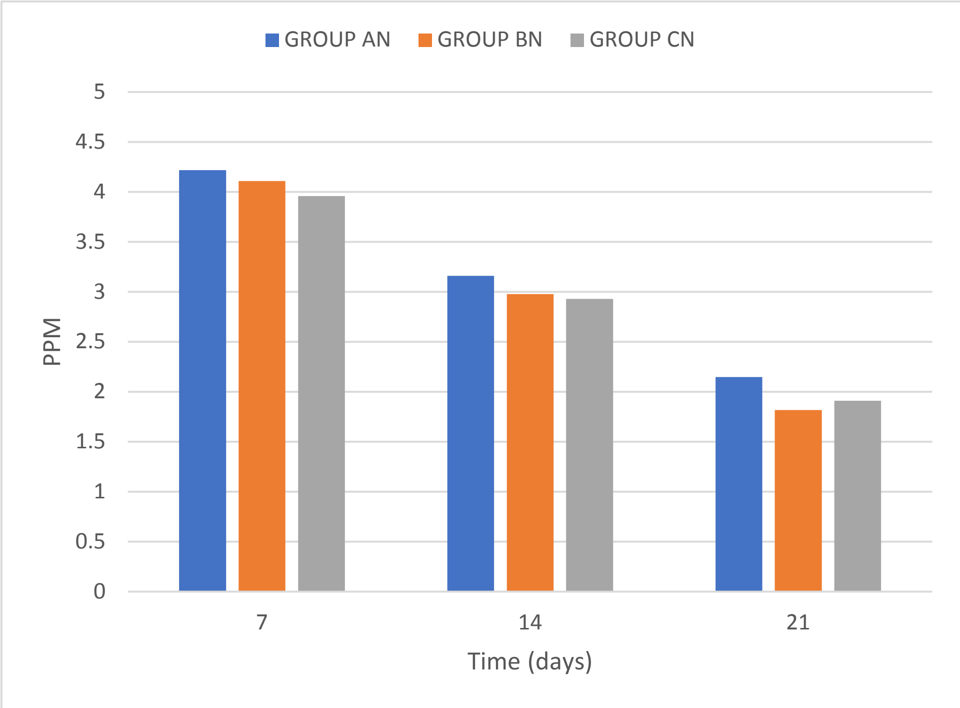
PLATE XI

OBSERVATION AND RESULTS

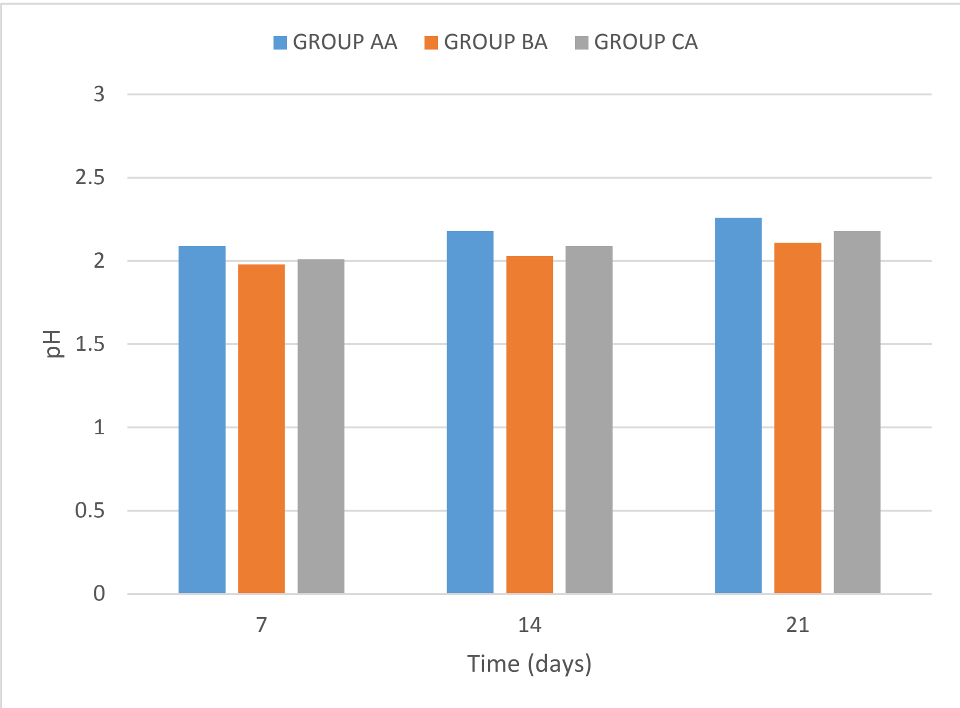
All the samples were incubated in 95% relative humidity environment at 37ºC until the period of testing. The cumulative fluoride ion release and change in pH were assessed at the end of 7 days, 14 days, and 21 days. The samples in neutral medium were tested for fluoride ion release and the samples in acidic medium (pH-4) were tested for pH change. The results so obtained were subjected to statistical analysis using ANOVA-F, Paired “t”, and Unpaired t-test.

Software: SPSS (Statistical Package for Social Sciences) Version 24.0 (IBM Corporation, Chicago, USA).

The mean values of fluoride ion release (ppm) and pH change from different subgroups at 7, 14, and 21 days as depicted in Table 1 and Table 2 respectively.
The probable values of paired t-test between subgroups of Groups AN, BN, CN and AA, BA, CA for fluoride ion release and pH change respectively is depicted in Table 3 and Table 4 respectively.



Graph 1: Comparison of mean Fluoride ion concentration among the tested groups



Graph 2: Comparison of mean values of pH change among the tested groups

Table 1: Mean values of fluoride ion release (ppm) of all the tested 9 subgroups at 7, 14 and 21 days in neutral (N) medium

DAYS	PARAMETER	GROUP AN	GROUP BN	GROUP CN
7	ppm	4.22	4.11	3.96
14	ppm	3.16	2.98	2.93
21	ppm	2.15	1.82	1.91

Table 2: Mean values of pH change of all the tested 9 subgroups at 7, 14 and 21 days in acidic (A) medium

DAYS	PARAMETER	GROUP AA	GROUP BA	GROUP CA
7	pH	2.09	1.98	2.01
14	pH	2.18	2.03	2.09
21	pH	2.26	2.11	2.18

Table 3: Probable values of paired t-test between subgroups for fluoride ion release (*A statistically significant difference at 0.05 level of significance (P<0.05))

TIME POINTS (DAYS)	PARAMETER	Probable values of paired t-test		
		AN	BN	CN
7	ppm	0.0001*	0.000*	0.0005
14	ppm	0.000*	0.000*	0.000*
21	ppm	0.005*	0.000*	0.001*

Table 4: Probable values of paired t-test between subgroups for pH change. (*A statistically significant difference at 0.05 level of significance (P<0.05))

TIME POINTS (DAYS)	**PARAMETER**	**Probable values of paired t-test**		
		AA	BA	CA
7	pH	0.0777	0.0610	0.4598
14	pH	0.7115	0.0589	0.6845
21	pH	0.1429	0.9424	0.2630

Fluoride Ion Concentration

All the materials tested released fluoride ions. The mean values of fluoride ion concentration were compared among 9 subgroups.

The fluoride release in subgroup AN7, AN14 and AN21 was significantly higher when compared to subgroup BN14, BN21and CN7, CN14 and CN21. However, there was no significant difference between the fluoride release in subgroup AN7 when compared with subgroup BN7 which was for a time period of 7 days. No significant difference was seen amongst subgroups BN14, BN21 and CN14, CN21 which was for a time period of 14 and 21 days respectively.

The fluoride ion release from all tested materials decreased with increasing period of time.

pH Change

All the 9 subgroups tested for pH change showed a statistically significant increase in pH in acidic medium.

An increase in the pH was seen in all materials with the increase in period of time. Subgroups AA7, AA14 and AA21 showed slightly higher pH increase when compared to subgroups BA7, BA14, BA 21. No significant difference was seen in increasing pH among groups AA and CA for all the time periods of 7, 14 and 21 days respectively.

DISCUSSION

The present in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Babu Banarasi Das College of Dental Sciences, Lucknow in collaboration with, Cytogene Research and Development Laboratory, Lucknow.

The aim of this study was to evaluate and compare fluoride ion release and alkalizing effect of Bulkfill composite (Cention-N), Giomer (Beautifil II) and Compomer (Dyract eXtra).

Restorative materials have been continuously developed for various reasons, for example with respect to dental caries, having high incidence of recurrent caries, treatment of high-caries risk patients who showed a higher degree of restoration failure, and in cases with the minimal-intervention approach.[39] 'Anticariogenic' materials play crucial role in inhibiting bacterial progression and encouraging mineral deposition into partially demineralised dentine. Currently, the ion-leaching restorative materials (ILM's) are amongst one group of restorative materials that may retard recurrent caries initiation, also enhances remineralisation, due to their ability to release ions such as fluoride (F^-) and hydroxyl (OH^-).[40]

Novel restorative materials have properties that respond to pH alterations in the oral cavity by uptake or release of calcium, phosphorous, fluoride ions and hydroxyl that helps in preserving the integrity of remaining tooth structure.[37] In case of pH drop in the oral environment, these materials can release various ions to neutralize the acid produced by the biofilm thus alkalizing the oral environmental pH. This would cause elimination of bacteria, prevent tooth demineralization, and enhance remineralization.[37]

The present in vitro study made a sincere attempt to evaluate and compare fluoride ion release and alkalizing effect of Bulkfill composite (Cention-N), Giomer (Beautifil II) and

Compomer (Dyract eXtra).The study design was based on the studies conducted by Nupur Gupta, Shikha Jaiswal, Vineeta Nikhil *et al*, 2019.[10]

In the present study, forty five human permanent mandibular molars were taken into consideration after accomplishing the inclusion and exclusion criteria. Mandibular molars were selected for this in vitro study as these teeth have a larger surface area allowing easier sectioning of the samples. For better simulation of clinical conditions, instead of artificial moulds used in other studies,the materials were placed in the prepared cavities on the selected tooth segment.[14,22,32] Cavities were made of 2mm x 2mm dimensions to maintain standardization throughout the study. Flat-end cylinder diamond point was used for cavity preparation to achieve the exact dimensions of the cavity. The unprepared enamel surface of the samples were coated with two layers of nail varnish, leaving a 1-mm window around the cavity margins to prevent ion release from the tooth surface which may cause overestimation of results.

The cavities in all the groups were restored using Teflon coated composite instruments with the respective allotted restorative materials to be tested. The materials were filled according to the manufacturer's instructions.

These restored 60 samples of all the three group were subdivided into two equal subgroups, comprising of 30 samples on the basis of pH (acidic pH–4 or neutral pH–6.8) of the solution to be used for testing. The subgroups representing acidic pH were labelled as AA, BA, and CA and subgroups representing neutral pH were labelled as AN, BN and CN respectively.

Finally, each of these subgroups were further divided into three subgroups on the basis of duration (7 days, 14 days, and 21 days) for which testing was done.

One-hundred and eighty samples were stored in deionized water for a period of 24 hours. The storage medium was renewed in 24 hours due to the possibility of saturation of released fluoride ions in the storage medium, which interferes with further release of fluoride ions.[28] After 24 hours, the containers were thoroughly shaken, samples were then removed. Every sample from the subgroup being tested for fluoride ion release was then immersed in fresh deionized water. Each sample was placed in a plastic container with 5 mL of deionized water. For the acidic medium, Lactic acid solution was used to achieve a pH of 4 in deionised water. Similarly every sample from the subgroup being tested for pH change was immersed in the acidic medium in plastic container containing this 5 mL of lactic acid medium.

The storage medium deionized water was selected over artificial saliva in this study, due to it's high viscosity and the presence of ions in the latter one. These ions would affect the release of fluoride ions from the restorative materials being tested, thus leading to an error in estimation of fluoride ion release and concentration.[1]

The detection of fluoride ion concentration was done by using a Fluoride meter. A Fluoride meter is an ion-selective electrode (ISE) which typically consists of an inner reference electrode plus a membrane that provides the interface between the sample solution and the ISE. A potential develops across the membrane that depends on the difference in the activity of a specific ion on each side of the membrane. According to Amra Bratovicic *et al,* there are some advantages of the use of Ion selective potentiometry which is accurate, fast, economic and sensitive in relation to the standard method, UV/VIS spectroscopy. The use of ion-selective electrodes enables the determination of ion species in a trace amount also.[41]

Amongst the fluoride-releasing restorative materials, conventional glass ionomer cements (GIC's) emerges at the top because of their efficacy in resisting secondary caries formation around restorations.[42] However, they are feeble in comparison to composite resins because of its high moisture sensitivity, low initial mechanical properties, and inferior translucency.

To overcome the shortcomings of GIC's while maintaining their clinical advantage in caries inhibition, Hybrid materials that purposely combines the benefits of both glass ionomers and composite resins were developed.[42] Examples include resin-modified Glass ionomer cements (RMGIC's), Polyacid-modified composite resins (compomers), and Giomers.

The materials compared in this current study includes a novel bulkfill alkasite material : Cention N (Group A), a giomer Beautifil II (Group B) and a compomer Dyract eXtra (Group C).

Cention N manufactured by Ivoclar Vivadent is available as powder and liquid. The powder consists of filler particles and other initiator components. Filler contains Barium aluminium silicate glass, Ytterbium trifluoride Radiopacity Isofiller (Tetric N-Ceram technology), Calcium barium aluminium fluorosilicate glass, for fluoride release: Calcium fluoro silicate glass Ion release F^-, OH^-, Ca^{2+}

The liquid consists of four different dimethacrylates monomers and initiators.

- Urethane dimethacrylate (UDMA) - main component of monomer matrix and has no hydroxyl side groups i.e. its hydrophobic and exhibits low water absorption.
- Tricyclodecan-dimethanol dimethacrylate (DCP) - low viscosity, difunctional monomer which initiates hand mixing of Cention N.
- Tetramethyl-xylylen-diurethane dimethacrylate (Aromatic aliphatic-UDMA) - partially aromatic urethane dimethacrylate is a hydrophobic, high-viscosity crosslinker which combines the favourable properties of aliphatic (low tendency to discolour) and aromatic (stiffness) diisocyanates.
- Polyethylene glycol 400 dimethacrylate (PEG-400 DMA) - enhances the flowability of Cention N.[27]

In the present study, Group A (Cention N) was tested for fluoride ion release for the time durations of 7, 14 and 21 days. The fluoride - ion release concentration (ppm) was found significantly higher viz 4.22, 3.16 and 2.15 for the time period tested for 7, 14 and 21 days respectively, when compared to the other subgroups.

Similar results were achieved by the study of Siddharth Rai *et al* where they compared the fluoride release and recharge capability of Cention N along with the other tested materials . It was observed that Cention N released significantly higher amounts of fluoride and had superior recharge capability. This high release of fluoride ions from Cention N may be attributed to the advanced filler technology used in this material manufacturing.[43]

Similar results were also observed in the study done by Harpreet Singh *et*. This new alkasite, Cention N showed promising results on long-term fluoride release, but it lacked an initial burst effect, which limits its antibacterial property after initial placement.[44]

The results of the present in-vitro study was found contrary with the findings of the study conducted by Walaa Mohamed *et al* that assessed the fluoride ion release capacity of Cention N. The study concluded that Cention N had an inferior fluoride release which can be due to the reason that Cention N lacks a burst effect but constantly releases fluoride over the period may be due to a higher powder/liquid ratio and also a high amount of alkaline glass in its final state.[45]

Regarding the evaluation of the alkalizing potential in the present in - vitro study, Cention N (Group A) showed higher pH change viz 2.09, 2.18 and 2.26 for the time periods 7, 14 and 21 days respectively, in comparison to the other groups tested.

Similar results were obtained in the study done by Nupur Gupta *et al* that evaluated the alkalizing potential of Cention N an in -vitro study using pH meter. It was found that the Cention N has highest alkalizing potential. This may be due to the hydroxyl and calcium ions release by alkaline glass fillers from Cention-N, which are able to have a direct effect on the pH levels in the oral cavity, thus creating for neutralisation of excess pH due to cariogenic bacterial activity.[1]

In contrast to the results of this in-vitro study, Shahin Kasraei *et al* compared the alkalizing potential of RMGIC, Activa BioActive, Cention N and Z250 composite and found that the Fuji II

LC had maximum alkalizing effect at all time points followed by Cention N. This may be due to the presence of poly-HEMA hydrogel phase in its composition that cause further water sorption and greater release of hydroxyl ions.[37]

In the present study, Group B (Beautifil II) giomer was tested for fluoride ion concentration (ppm) and pH change for the time durations of 7, 14 and 21 days.

Beautifil II, giomer is manufactured by Shofu, Japan. Giomers have pre-reacted glass ionomer (PRG) cements as fillers, where fillers are prepared by the acid-base reaction of a fluoro aluminosilicate glass with polyalkenoic acid in water prior to inclusion into the urethane resin.[46]

Beautifil II used in this study is a fluoride-releasing, light-cured, nano-hybrid composite indicated for Class I- Class V restorations, wedge-shaped defects and root caries, direct laminate veneer, core build-up, and repair of restorations. It is composed of BISGMA, Triethylene glycol methacrylate, inorganic glass filler, aluminium oxide, silica, pre reacted glass ionomer filler and camphoroquinone.[46]

Beautifil II, contains a glass-ionomer matrix with fluoridated glass filler. It is a second-generation giomer which uses surface pre-reacted glass-ionomer (SPRG) filler technology, where only the surface of the fluoridated glass filler reacts with polyacrylic acid in an acid-base reaction in the presence of water to form a thick siliceous hydrogel layer while the glass core remains intact. Therefore, unlike compomers, fluoroaluminosilicate glass particles in giomers react with polyacrylic acids prior to incorporation into the resin matrix. Fluoride release from giomers was reportedly slightly higher than composite resins but lower than glass ionomer cements.[47]

In the present study, Group B (Beautifil II) was tested for fluoride ion concentration (ppm) for the time durations of 7, 14 and 21 days. The fluoride ion release concentration (ppm) for Group B were 4.11, 2.98 and 1.82 for the time duration 7, 14 and 21 days respectively. On comparison with other tested groups, the results showed that there was no statistically significant difference when compared with Group C(Dyract eXtra) and Group A(viz 4.22 and 3.96 respectively in fluoride ion release concentration (ppm) at the time duration of 7 days.

Similarly, Group B and Group C had no statistically significant difference in the fluoride ion concentration (ppm) viz 2.98 and 2.93; 1.82 and 1.91 for the time duration of 14 and 21 days respectively.

In contrast to the results obtained in the present study, Dimitrios Dionysopoulos *et al* evaluated the fluoride release in their in vitro study for five restorative materials namely Fuji IX GP, Ketac N100, 3M ESPE, Dyract Extra, Beautifil II and Wave. Among the restorative materials tested, Fuji IX GP released the highest amount of fluoride ions followed by Ketac N100 and Dyract Extra while Beautifil II and Wave did not show any significant difference. This can be attributed due to the mechanism by which GICs release fluoride into an aqueous environment is proposed to comprise two processes. Process I is a short-term reaction which involves rapid dissolution of fluoride from the outer surface into the solution whereas Process II is more gradual and results in a sustained diffusion of fluoride through the bulk cement.[48]

Group B (Beautifil II) was tested for pH change for the time durations of 7, 14 and 21 days. The values of pH in Group B increased for all time durations viz 1.98, 2.03 and 2.11 for 7, 14 and 21 days respectively. On comparing with other tested groups, it was revealed that there was no statistically significant difference seen between Group B (Beautifil II) and Group C (Dyract eXtra). However, pH change in Group B (Beautifil II) was significantly lower than Group A (Cention N) viz 1.98, 2.03 and 2.11 at the time durations of 7,14 and 21 days respectively.

Similar results were obtained in the study conducted by Katarina Kelic *et al* that concluded that Beautifil II showed less alkaline pH than Cention N. This is attributed due to change in diffusion gradient between the material and the immersion medium. The variation in pH for restorative material could be due to different specimen geometry and different specimen media.[49]

Similar results were observed in the research conducted by S Naoum *et al* that determined the fluoride ion release and recharge capabilities of three fluoride containing resin composites namely Beautifil II, Gradia Direct X and Tetric EvoCeram and also a convention GIC Fuji IX Extra was compared using a fluoride specific electrode. The cumulative fluoride released and recharge capacity from Beautifil II in the media was substantially greater than the fluoride released from Gradia Direct X and Tetric EvoCeram but it did not exceed that of the conventional GIC. This may be due to the placement of unfilled resin over glass ionomers reduces the level of fluoride release by a factor of 1.5 to 4 times, which follows that the post recharge fluoride release from Beautifil II would be comparable and would potentially exceed the ‘‘plateau release’’ of glass ionomers that have demonstrated caries inhibition.[50]

In contrast to the results of this study, S M Abdul Quader *et al* , conducted an in vitro study comparing the fluoride release and recharge ability of a composite Quixfil, compomer Dyract eXtra and a giomer Beautifil II. The results showed that the fluoride release capability of Giomer becomes low in comparison to Glass Ionomer but not significant in comparison to compomer. This can be attributed to the fact that Fluoride release from glass ionomer restorations increases the fluoride concentration in saliva and in adjacent hard dental tissues. Thus, continuous small amounts of fluoride surrounding the teeth decreases demineralization of the tooth tissues although, it is not proven by prospective clinical studies whether the incidence of secondary caries can be significantly reduced by the fluoride release of restorative materials.[51]

In contrast to the results of the present study, Bansal *et al* in vitro study evaluated fluoride release and recharging potential of : Conventional Glass Ionomer Cement (Fuji II), Light Cure Resin

Modified GIC (Fuji II LC), Giomer (Beautifil II), Compomer (Dyract). This study concluded that, the initial Fluoride release was highest from Conventional GIC followed by Resin Modified GIC, Giomer and Compomer and same was the case in their fluoride recharge capabilities. Compomers contains a mixture of cycloaliphatic dicarboxylic acid dimethacryiate substitute for carboxylic acid and reactive glass fillers. It may be due to the initially light polymerized material takes up water with time and that the carboxylic groups of the acidic monomer can undergo acid base reaction with metal ions of glass filler. Fluoride release may occur in response to water uptake subsequent to dissolution of the glass filler particles or the ionic reaction on the surface of the glass particles. Glass ionomer formulations can be recharged and release fluoride slowly after exposure to fluoride solutions such as toothpaste and fluoride rinses. This may be clinically important because glass ionomer restorations may act as intraoral devices for the controlled slow release of fluoride at sites at risk for recurrent caries. Composites and Compomers, however, do not seem to have this ability. Giomers uses pre reacted glass ionomer technology to form a stable phase of GIC in the restoration. The more extensive acid base reaction and hydrogel layer of glass fillers are responsible for high amount of release in giomers when compared to compomers.[42]

Dyract Extra , a compomer restorative material was chosen in the present study for Group C.The word “Compomer” is derived from two words: “composite” and “glass ionomers.” Compomers, or polyacid-modified composite resins. Compomers are a category of restoratives that includes the chemical composition of composites and glass ionomers. This material is an amended composite of polyacrylic-/polycarboxylic acid. The point of compomers is to combine the beneficial properties of glass ionomers by using composite technology.[15] In vitro studies have shown that compomers released considerably less fluoride than conventional GICs and RMGICs over time. Moreover, unlike GICs and RMGICs, compomers produced no initial “burst” of fluoride.[8]

Dyract Extra contains a mixture of monomers and reactive glass fillers containing SrF_2. These glass fillers are identical to the ion leachable glass fillers used in conventional GICs, but in smaller sizes than those used in most composite resins. Initial setting is due to photopolymerization, followed by an acid-base reaction that arises from sorption of water.[19] In vitro studies have shown that compomers releases considerably less fluoride ions than conventional GICs and RMGICs with time. Moreover, unlike GICs and RMGICs, compomers exhibit no initial "burst" of fluoride. Their levels of fluoride release remained low and relatively constant over time.[43]

In the current study, (Dyract eXtra) Group C was tested for fluoride ion concentration (ppm) for the time durations of 7, 14 and 21 days. The fluoride ion release concentration in Group C were On comparison with other tested groups, the results showed that there was no significant difference between group C and group B in fluoride ion release concentration (ppm) viz 3.96 and 4.11; 2.93 and 2.98; 1.91 and 1.82 at the time duration of 14 and 21days respectively.

The results seen in the current study were similar to another in vitro study done by Sayed Mostafa Mousavinasab *et al*, which compared the amounts of fluoride released from fluoride-containing materials, four glass ionomer cements (Fuji IX, Fuji VII, Fuji IX Extra and Fuji II LC), a compomer (Dyract Extra) and a giomer (Beautifil). Here, Dyract eXtra showed the least amount of fluoride ion release in comparison to the other materials. This can be attributed to the porosity of the materials may have a great influence on the amounts of fluoride release.[28]

In contrast to the results of this study S M Abdul Quader *et al* , conducted an in vitro study comparing the fluoride release and recharge ability of a composite Quixfil, compomer Dyract eXtra and a giomer Beautifil II. The results showed that the fluoride release capability of Giomer becomes low in comparison to Glass Ionomer but not significant in comparison to compomer. This can be attributed to the fact that Fluoride release from glass ionomer restorations increases the fluoride concentration in saliva and in adjacent hard dental tissues. Thus, continuous small amounts of fluoride surrounding the teeth decreases demineralization of the tooth tissues although, it is not proven by prospective clinical studies whether the incidence of secondary caries can be significantly reduced by the fluoride release of restorative materials.[51]

In the current study, (Dyract eXtra) Group C was tested for pH change for the time durations of 7, 14 and 21 days. There was a rise in pH seen in Group C at all time durations viz 2.01, 2.09 and 2.18 for 7, 14 and 21 days respectively. On comparing the results of Group C with other tested groups regarding the ph change, it was seen that Group C (Dyract eXtra) showed higher ph increase than Group B. This can be attributed due to the release of ions (Al, Sr) from reactive glass components of the compomer. Moreover, the total fluoride was found to be higher than the free fluoride ion in this compomer that can be one of the factors that neutralizes pH and stops demineralization by buffering the pH.[14]

The literature regarding the alkalizing potential of Dyract eXtra is scares. Therefore, more further studies are needed to come to a decisive conclusion.

CONCLUSION

The present in vitro study evaluated and compared the fluoride ion release and alkalizing effect by Bulkfill composite (Cention-N), Giomer (Shofu Beautifil II) and Compomer (Dyract eXtra).

Within the limitations of this study the following conclusions were drawn:

1. All restorative materials release fluoride at all time intervals viz 7, 14 and 21 days.
2. The fluoride ion release from all tested materials decreased with increasing period of time.
3. Cention N shows the highest fluoride ion release when compared to Beautifil II and Dyract eXtra.
4. All restorative materials showed an increase in pH at all time durations viz 7, 14 and 21 days
5. The increase in pH was seen in all materials with the increase in the period of time.
6. Statistically no significant difference was found in the pH change or alkalizing potential of all the tested restorative materials.
7. Cention N showed the highest pH change or alkalizing potential followed by Dyract eXtra and Beautifil II.

BIBLIOGRAPHY

1. Gupta N, Jaiswal S, Nikhil V, Gupta S, Jha P, Bansal P. Comparison of fluoride ion release and alkalizing potential of a new bulk-fill alkasite. J Conserv Dent. 2019 May-Jun;22(3):296-299
2. Bali P, Prabhakar AR, Basappa N. An Invitro Comparative Evaluation of Compressive Strength and Antibacterial Activity of Conventional GIC and Hydroxyapatite Reinforced GIC in Different Storage Media. J Clin Diagn Res. 2015 Jul;9(7):ZC51-5
3. Mazumdar P, Das A, Das UK. Comparative evaluation of microleakage of three different direct restorative materials (silver amalgam, glass ionomer cement, cention N), in Class II restorations using stereomicroscope: An in vitro study. Indian J Dent Res 2019;30:277-81
4. Manuja N, Pandit I K, Srivastava N, Gugnani N, Nagpal R. Comparative evaluation of shear bond strength of various esthetic restorative materials to dentin: An in vitro study. J Indian Soc Pedod Prev Dent 2011;29:7-13
5. P.Laxmish Mallya , Ravindra Kotian , Prashanthi M , Srikant N. Comparative Evaluation of Cention with Glass Ionomer Cement, Composite Resins and Silver Amalgam with Respect to Mechanical Strength: An in-Vitro Study. Indian Journal of Forensic Medicine & Toxicology, 2004; 14(3), 507–510.
6. Iftikhar N, Devashish, Srivastava B, Gupta N, Ghambir N, Rashi-Singh. A Comparative Evaluation of Mechanical Properties of Four Different Restorative Materials: An *In Vitro* Study. Int J Clin Pediatr Dent. 2019; Jan-Feb;12(1):47-49.
7. Shenoi PR, Kokane VB, Thawale HV, Kubde RR, Gunwal MK, Shahu SP. Comparing marginal microleakage in Class V cavities restored with flowable composite and Cention-N using confocal microscope-an in-vitro study. Indian J Dent Res 2021; 32:348-53.
8. Nicholson, John. Polyacid-modified composite resins (“compomers”) and their use in clinical dentistry. Dental materials : Academy of Dental Materials.2007;23. 615-22.

9. Rusnac ME, Gasparik C, Irimie AI, Grecu AG, Mesaroş AŞ, Dudea D. Giomers in dentistry at the boundary between dental composites and glass-ionomers. Med Pharm Rep. 2019 Apr;92(2):123-128.
10. B.F. El Mallakh, N.K. Sarkar, Fluoride release from glass-ionomer cements in de-ionized water and artificial saliva. Egypt. Dent Mater, 1990; 6:118-122
11. Forsten L. Short- and long-term fluoride release from glass ionomers and other fluoride-containing filling materials in vitro. Scand J Dent Res. 1990 Apr;98(2):179-85.
12. Creanor SL, Carruthers LM, Saunders WP, Strang R, Foye RH. Fluoride uptake and release characteristics of glass ionomer cements. Caries Res. 1994;28(5):322-8.
13. Silvana M. Berlacchini, V Pablo R Abale, Adriana Blank, Maria R Bagliet, Ricardo L. Macclii "Solubility and fluoride release in ionomers and compomers. Quintessence International, 1999;30(3):193-97.
14. Nicholson JW, Aggarwal A, Czarnecka B, Limanowska-Shaw H. The rate of change of pH of lactic acid exposed to glass-ionomer dental cements. Biomaterials. 2000 Oct;21(19):1989-93.
15. Yip HK, Smales RJ. Fluoride release from a polyacid-modified resin composite and 3 resin-modified glass-ionomer materials. Quintessence Int. 2000 Apr;31(4):261-6.
16. Vermeersch G, Leloup G, Vreven J. Fluoride release from glass-ionomer cements, compomers and resin composites. J Oral Rehabil. 2001 Jan;28(1):26-32
17. Helvatjoglu-Antoniades M, Karantakis P, Papadogiannis Y, Kapetanios H. Fluoride release from restorative materials and a luting cement. J Prosthet Dent. 2001 Aug;86(2):156-64.
18. Chacko Y, Lakshminarayanan L. pH stabilizing properties of a posterior light cured resin composite: an in vivo study. Oper Dent. 2001 May-Jun;26(3):219-22.
19. Kawai K, Takaoka T. Fluoride, hydrogen ion and HEMA release from light-cured GIC restoratives. Am J Dent. 2002 Jun;15(3):149-52

20. van Dijken JW. Three-year performance of a calcium-, fluoride-, and hydroxyl-ions-releasing resin composite. Acta Odontol Scand. 2002 Jun;60(3):155-9.
21. Yap, Adrian & Tham, SY, Zhu, LY & Lee HK. Short-term fluoride release from various aesthetic restorative materials. Operative dentistry. 2002 ;27. 259-65.
22. Carey CM, Spencer M, Gove RJ, Eichmiller FC. Fluoride release from a resin-modified glass-ionomer cement in a continuous-flow system. Effect of pH. Journal of Dental Research. 2003 Oct;82(10):829-832.
23. Passi P, Zadro A, Varotto S, Berengo M, Haessler D. In vitro buffering properties of 3 composite resins. Minerva Stomatologica. 2004 Apr;53(4):125-134.
24. Nicholson, John & Czarnecka, Beata. The release of ions by compomers under neutral and acidic conditions. Journal of oral rehabilitation. 2004; 31. 665-70.
25. Itota T, Carrick TE, Yoshiyama M, McCabe JF. Fluoride release and recharge in giomer, compomer and resin composite. Dent Mater. 2004 Nov;20(9):789-95
26. Persson A, Lingstrom P, van Dijken JW. Effect of a hydroxyl ion-releasing composite resin on plaque acidogenicity. Caries Research. 2005 May-Jun;39(3):201-206
27. Delbem AC , Pedrini, Denise , JG França, & TM Machado. Fluoride release by restorative materials before and after a topical application of fluoride gel. Pesquisa odontológica brasileira = Brazilian oral research. 2003; 17. 137-41.
28. Mousavinasab SM, Meyers I. Fluoride release by glass ionomer cements, compomer and giomer. Dent Res J (Isfahan). 2009 Fall;6(2):75-81.
29. K Anupama & Hegde V. A short term comparitive analysis of Fluoride release from a newly introduced Glass Ionomer Cement in deionised water and lactic acid. Journal of International Oral Health, 2010; 2. 71-78.
30. Neelakantan P, John S, Anand S, Sureshbabu N, Subbarao C. Fluoride release from a new glass-ionomer cement. Oper Dent. 2011 Jan-Feb;36(1):80-5.

31. Moreau JL, Xu HH. Fluoride releasing restorative materials: Effects of pH on mechanical properties and ion release. Dental Materials : Official Publication of the Academy of Dental Materials. 2010 Nov;26(11):e227-35.
32. Jingarwar MM, Pathak A, Bajwa NK, Sidhu HS. Quantitative assessment of fluoride release and recharge ability of different restorative materials in different media: an in vitro study. J Clin Diagn Res. 2014 Dec;8(12):ZC31-4.
33. . Markus Fuss, Michael J Wicht, Thomas Attin, Sonja H M Derman, Michael J Noack .The journal of adhesive dentistry *1*9 2 (2017): 177-183 .
34. Porenczuk A, Jankiewicz B, Naurecka M, Bartosewicz B, Sierakowski B, Gozdowski D, Kostecki J, Nasiłowska B, Mielczarek A. A comparison of the remineralizing potential of dental restorative materials by analyzing their fluoride release profiles. Adv Clin Exp Med. 2019 Jun;28(6):815-823.
35. Kelić K, Par M, Peroš K, Šutej I, Tarle Z. Fluoride-Releasing Restorative Materials: The Effect of a Resinous Coat on Ion Release. Acta Stomatol Croat. 2020 Dec;54(4):371-381.
36. Balagopal S, Nekkanti S, Kaur K. An In Vitro Evaluation of the Mechanical Properties and Fluoride-releasing Ability of a New Self-cure Filling Material. J Contemp Dent Pract. 2021 Feb 1;22(2):134-139.
37. Kasraei S, Haghi S, Valizadeh S, Panahandeh N, Nejadkarimi S. Phosphate Ion Release and Alkalizing Potential of Three Bioactive Dental Materials in Comparison with Composite Resin. Int J Dent. 2021 May 7;2021:5572569.
38. Lehmann-Kalata Anna , Nijakowski Kacper , Nowakowska, Michalina , Woś, Patryk , Misiaszek, Maria & Surdacka, Anna. Influence of Selected Restorative Materials on the Environmental pH: In Vitro Comparative Study. Applied Sciences. 2021; 11. 11975. 10.3390
39. Kateeb ET, Warren JJ. The transition from amalgam to other restorative materials in the U.S. predoctoral pediatric dentistry clinics. Clin Exp Dent Res. 2019;5(4):413-419.

40. ten cate, Jacob. Remineralization of deep enamel dentin caries lesions. Australian dental journal. 2008; 53. 281-5.

41. Amra Bratovcic, Amra Odobasic , Sead Catic.The Advantages of the Use of IonSelective Potentiometry in Relation to UV/VIS Spectroscopy, Agriculturae Conspectus Scientifi cus , 2009; 74 (3):139-142

42. Bansal R, Bansal T. A Comparative Evaluation of the Amount of Fluoride Release and Re-Release after Recharging from Aesthetic Restorative Materials: An in vitro Study J Clin Diagn Res. 2015;9(8):ZC11-ZC14

43. Rai S, Kumari RA, Meena N. Comparative assessment of fluoride release and recharge through newer fluoride releasing posterior restorative materials: An in vitro study. J Conserv Dent. 2019;22(6):544-547.

44. Singh H, Acharya Rashmi, S. Pai and Kini, S. Comparative evaluation of fluoride release from two different glass ionomer cement and a novel alkasite restorative material – An in vitro study. Pesquisa Brasileira em Odontopediatria e Clinica Integrada, 2020, [e5209].

45. Alsamolly, Walaa & Sadek, Galal. Comparative assessment of antibacterial activity and fluoride release potential of Cention-N and different bioactive restorative materials: An in vitro study. Egyptian Dental Journal. 2017; 67. 2795-2803.

46. Colceriu Burtea L, Prejmerean C, Prodan D, et al. New Pre-reacted Glass Containing Dental Composites (giomers) with Improved Fluoride Release and Biocompatibility. Materials (Basel). 2019;12(23):4021. Published 2019 Dec 3.

47. Harhash, A. Y., ElSayad, I. I., & Zaghloul, A. A comparative in vitro study on fluoride release and water sorption of different flowable esthetic restorative materials. European journal of dentistry, 2020; 11(2), 174–179.

48. Dimitrios Dionysopoulos, Eugenia Koliniotou-Koumpia, Nikolaos Kotsanosc The Effect of Low Concentration Fluoride Solutions On The Fluoride Recharge Ability Of

Contemporary Dental Restoratives And Adhesives; Research report Fluoride. 2015; 48(4)345-357

49. Katarina Kelic, Matej Par, Kristina Peros, Ivana Sutej, and Zrinka Tarle . “Fluoride-Releasing Restorative Materials: The Effect of a Resinous Coat on Ion Release.” Acta Stomatologica Croatica 54. 2020: 371 - 381.

50. Naoum S, Ellakwa A, Martin F, Swain M. Fluoride release, recharge and mechanical property stability of various fluoride-containing resin composites. Oper Dent. 2011 Jul-Aug;36(4):422-32.

51. Quader, S. A., Alam, M. S., Bashar, A., Gafur, A., & Mansur, M. A. Compressive Strength, Fluoride Release and Recharge of Giomer. Update Dental College Journal, 2013; 2(2), 28–37.

ANNEXURE-I

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the VIIIth Institutional Ethics Sub-Committee

IEC Code: 02 **BBDCODS/03/2020**

Title of the Project: A Comparitive Evaluation of Fluoride ion Release and Alakalizing Potential of a New Bulkfill Composite, Giomer and Compomer: An *In-Vitro* Study.

Principal Investigator: Dr. Prachi Mishra **Department:** Conservative Dentistry and Endodontics

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr. Prachi Mishra,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 18th March 2020.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Sahana S. Member	Reader, Department of Public Health Dentistry, BBDCODS, Lucknow
4.	Dr. Sumalatha M.N. Member	Reader, Department of Oral Medicine & Radiology, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala 18/03/2020

(Dr. Lakshmi Bala)
Member-Secretary
IEC

Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. B. Rajkumar)
Principal
BBDCODS

PRINCIPAL
Babu Banarasi Das College of Dental Science
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

ANNEXURE-II

To,

TO WHOMSOEVER IT MAY CONCERN

Subject:
Certificate of Original Work

*This is to certify that **Dr. Prachi Mishra,** P.G. Resident, Department of Conservative Dentistry & Endodontics, Babu Banrasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow (U.P.) has carried out part of her research study at our laboratory. The details of work are given below:*

Date:
12th Jan 2022

S. No.	Description of Work	Sample Collected On	Result Delivered on
1	pH Measurement	04th Jan 2022	12th Jan 2022
2	Quantification of Fluoride ion		

Reference No:
CG/2201/1202

The results obtained are outcome of her independent and original work and has not been published previously.

We wish her all the best in her future endeavors

Yours Sincerely,

Er. Sujeet Kumar Singh
Director

Address:
CSC (B) – 301, 2nd floor
Old Complex, Sahara States
Jankipuram,
Lucknow - 226021

Contact:
General
+91 – 77-0309-2222
Training
+91 – 77-0309-3333
Testing
+91 – 77-0309-4444
Workshop
+91 – 77-0309-5555

Email:
services@cytogene.in
cytogenernd@gmail.com

ANNEXURE-III

GROUP	DAY	FLOURIDE ION CONC(PPM)		FLOURIDE ION CONC(PPM)(mean)
AN7	7	4.54		4.22
AN7	7	4.67		
AN7	7	4.07		
AN7	7	4.02		
AN7	7	4.33		
AN7	7	4.39		
AN7	7	3.70		
AN7	7	3.71		
AN7	7	3.94		
AN7	7	4.19		
AN14	14	3.59		3.16
AN14	14	2.70		
AN14	14	3.08		
AN14	14	3.35		
AN14	14	2.93		
AN14	14	3.45		
AN14	14	3.49		
AN14	14	2.72		
AN14	14	3.10		
AN14	14	2.64		
AN21	21	2.07		2.15
AN21	21	2.41		
AN21	21	1.71		
AN21	21	2.44		
AN21	21	1.66		
AN21	21	2.02		
AN21	21	2.46		
AN21	21	2.48		
AN21	21	2.49		
AN21	21	2.46		
BN7	7	3.75		4.11
BN7	7	3.75		
BN7	7	4.25		
BN7	7	4.38		
BN7	7	4.44		
BN7	7	3.98		
BN7	7	4.09		
BN7	7	3.70		
BN7	7	3.93		
BN7	7	4.52		
BN14	14	3.06		2.98
BN14	14	2.55		
BN14	14	3.17		
BN14	14	2.61		

BN14	14	3.23		
BN14	14	2.88		
BN14	14	3.01		
BN14	14	3.06		
BN14	14	3.48		
BN14	14	2.67		
BN21	21	1.64		1.82
BN21	21	2.19		
BN21	21	1.93		
BN21	21	1.71		
BN21	21	1.42		
BN21	21	1.95		
BN21	21	2.32		
BN21	21	1.65		
BN21	21	1.60		
BN21	21	1.75		
CN7	7	3.74		3.96
CN7	7	4.19		
CN7	7	3.67		
CN7	7	3.76		
CN7	7	3.98		
CN7	7	4.23		
CN7	7	3.55		
CN7	7	3.61		
CN7	7	4.07		
CN7	7	3.80		
CN14	14	2.71		2.93
CN14	14	2.63		
CN14	14	2.64		
CN14	14	2.86		
CN14	14	2.58		
CN14	14	2.56		
CN14	14	3.51		
CN14	14	3.36		
CN14	14	3.50		
CN14	14	3.12		
CN21	21	2.25		1.91
CN21	21	1.70		
CN21	21	2.36		
CN21	21	2.28		
CN21	21	1.55		
CN21	21	1.52		
CN21	21	2.01		
CN21	21	1.94		
CN21	21	2.22		
CN21	21	1.59		

GROUP	DAY	pH
AA7	7	6.47
AA7	7	6.53
AA7	7	5.83
AA7	7	6.28
AA7	7	5.82
AA7	7	6.51
AA7	7	6.58
AA7	7	5.93
AA7	7	6.37
AA7	7	6.43
AA14	14	6.36
AA14	14	6.16
AA14	14	5.68
AA14	14	5.90
AA14	14	6.41
AA14	14	5.68
AA14	14	6.45
AA14	14	6.01
AA14	14	6.25
AA14	14	6.44
AA21	21	5.71
AA21	21	6.12
AA21	21	5.69
AA21	21	5.98
AA21	21	6.43
AA21	21	5.76
AA21	21	6.25
AA21	21	5.99
AA21	21	5.95
AA21	21	6.23
BA7	7	5.59
BA7	7	5.84
BA7	7	5.67
BA7	7	5.70
BA7	7	6.13
BA7	7	5.93
BA7	7	5.46
BA7	7	5.82
BA7	7	6.11
BA7	7	5.87
BA14	14	6.44
BA14	14	5.90
BA14	14	5.93

BA14	14	6.48
BA14	14	6.53
BA14	14	6.04
BA14	14	5.86
BA14	14	6.38
BA14	14	5.86
BA14	14	6.41
BA21	21	6.25
BA21	21	5.95
BA21	21	6.10
BA21	21	5.91
BA21	21	5.90
BA21	21	6.53
BA21	21	6.15
BA21	21	6.44
BA21	21	5.75
BA21	21	6.44
CA7	7	6.14
CA7	7	6.54
CA7	7	5.63
CA7	7	6.38
CA7	7	5.86
CA7	7	6.41
CA7	7	6.25
CA7	7	6.47
CA7	7	6.16
CA7	7	6.14
CA14	14	5.91
CA14	14	6.37
CA14	14	6.48
CA14	14	5.84
CA14	14	6.40
CA14	14	6.18
CA14	14	6.47
CA14	14	5.65
CA14	14	6.11
CA14	14	6.12
CA21	21	6.47
CA21	21	6.25
CA21	21	5.74
CA21	21	6.36
CA21	21	5.85
CA21	21	6.35
CA21	21	5.70
CA21	21	5.85
CA21	21	5.74
CA21	21	5.70

ANNEXURE-IV

Curiginal

Document Information

Analyzed document	ind.docx (D132940959)
Submitted	2022-04-07T14:56:00.0000000
Submitted by	Vishesh Gupta
Submitter email	drvisheshgupta@bbdu.ac.in
Similarity	2%
Analysis address	drvisheshgupta.bbduni@analysis.urkund.com

Sources included in the report

W	URL: https://www.sciencedirect.com/topics/chemistry/compomer Fetched: 2019-11-22T08:39:11.2930000	1
W	URL: https://pdfs.semanticscholar.org/52a4/7088ec9db7c76f73f39eff0c05cbceae47be.pdf Fetched: 2022-04-07T14:58:48.4300000	1
W	URL: https://www.researchgate.net/publication/262642918_Fluoride_release_recharge_and_flexural_properties_of_polymethylmethacrylate_containing_fluoridated_glass_fillers Fetched: 2021-01-21T10:54:10.8670000	1