GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 12 (345) Декабрь 2023

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman** (**Кириллица**), ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

Содержание:

MARGINAL FITNESS OF BIOACTIVE BULKFILL RESTORATIONS TO GINGIVAL ENAMEL OF CLASS II CAVITIES: AN IN VITRO COMPARATIVE STUDY

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Abstract.

Objective: This study's goal was to assess the marginal fitness for the two bioactive bulkfill restorative materials in Cl. II cavities regarding the storage in PBS.

Methods: Twenty-four sound molars with nearly same size were placed in PVC tube, showing 3 mm below the CEJ; divided into three major groups (n=8) based on type of restorative materials. Each tooth exposed to two independed MO and DO cavities preparation. After cavities restorations and samples thermocycling, each group was further separated into two subgroups (n=4); the first subgroup does not undergo storage. While the second subgroup was stored for 28 days in PBS. After that all teeth samples were sent for FESEM/EDX analyses. Statistical analyses were be done using "Two-Way ANOVA" and "Duncan's Multiple Range" test to evaluate and compare the results at 5% significant level.

Result: According to the study, there was a statistically significant difference at ($P \leq 0.05$) between the groups in the term of gap width formation in µm at the interface between restorative materials and gingival enamel margin, group (C1: Predicta bioactive non-storage) represent the highest mean of gap width (11.76 ± 2.07), while group (A1: Tetric powerFill non-storage) represent the lowest mean of gap width (6.08 ± 1.36).

Conclusion: The marginal adaptation at the interface between resin restorative material and gingival enamel margin can be affected by the composition and the properties of the restorative materials used. The bioactive restorative materials showed statistically significant reduction in gaps width after storage in PBS for 28 days.

Key words. Predicta bulk bioactive, Cention N, marginal fitness, FESEM/EDX.

Introduction.

Over the recent years, the preferred materials for restoring not only anterior but also the posterior teeth are direct esthetic restorative materials [1]. The main scope of operative dentistry is to remove carious lesion and replaced it with restorative materials with satisfactory bonding characteristic at the tooth-restoration interface to create a high-quality seal [2]. Actually, there is a continuous evolution in composite restorations, this includes developments in monomers, fillers, photo-initiators and even in application techniques [3]. Unfortunately, despite this progression a problem such as polymerization shrinkage still a challenge for the clinicians [4]. Resin composite polymerization shrinkage consider as "inherent property of the material" result in problems such as inadequate restoration adaptation to tooth structure, marginal gaps, microleakage, tooth sensitivity, recurrent caries and even pulp pathosis [5]. Shrinkage stress can be affected by many factors, among them, the composition of resin matrix, filler content and type, the size and geometry of cavity, the application technique, and the material characteristic (including the modulus of elasticity) [6]. One of the solutions to improve sealing problem of the posterior composite resin restoration is the incremental technique for restoration application. However, time consuming due to multiple steps procedure, voids incorporation and lack of adherence between increments develop the necessity for another application technique [7,8]. The production of bulk fill resin-based materials considers as turning point in restorative dentistry. Hence, these materials allow the application of 4-5 mm as one increment without affecting polymerization efficiency, this speed of the restorative procedure and reduce complexity [9,10]. Recently, advances in restorative materials progressed by developing restorative materials that not only replaced missing tooth structure but also inoculation of bioactive components that have the ability to re-mineralized tooth structure by releasing ions such as "calcium, phosphate and fluoride", thus provide tight seal at the tooth-restoration interface and induce apatite formation [11,12]. Nowadays, there are many questions about the bioactivity of restorative materials and their ability to adequately seal the marginal gaps. Therefore, the goals of current study are to measure the marginal fitness of two bioactive restorative materials: Cention N (Ivoclar viva-dent, Liechtenstein) and Predicta bioactive (Parkell, USA) and compared with a new type of bulkfill composite which is Tetric powerFill (Ivoclar viva-dent, Liechtenstein) before and after the storage in phosphate buffered saline (PBS) for 28 days with the aid of field emission scanning electron microscope (FESEM) and X-ray dispersive energy spectroscopy (EDX). The null hypothesis was there is no significant difference in gaps width regarding restorative material types and storage period.

Materials and Methods.

Sample collection and preparation: In this investigation, twenty-four human molars extracted for orthodontic purposes from patients between the ages of 20 and 30 were utilized. The collected teeth with nearly equal size (the bucco-lingual and mesio-distal length difference less than 1 mm) were scaled with scaler (Woodpecker, Germany) to remove any calculus and periodontal tissue appurtenances then the teeth were cleaned with eugenol-free pumice (Master-Dent, USA). The chosen teeth passed the stereomicroscope (Optika, Italy) 10X magnification examination without defects or cracks. The teeth were kept in 0.1% thymol solution for disinfection for two weeks and then kept in distilled water inside a screw-capped glass container throughout the collection period, at room temperature, until the next step [13].

Cavity preparation and sample grouping: The root apices of each tooth was sealed with flowable composite then each tooth was mounted in polyvinylchloride tube (PVC) with the aids of the surveyor in such way that long axis of the tooth parallel to the long axis of PVC tube. The occlusal surface of each cusp with slight height than other cusps was reduced in order to obtain flat enamel surface, this step was necessary to provide a nearly flat surface to standardize the position of light curing unit [5,14]. Each tooth prepared with two independed Class II proximal box cavities (mesially and distally) located 1mm coronal to CEJ with mesio-distal width: 1.5 mm, bucco-lingual width: 2 mm, occluso-gingival: 4mm [15,16], and they were prepared utilizing a high-speed, air/water spray and a parallel-sided, (1.2 mm) diameter diamond fissure bur (Komet, Germany) with the aid of modified dental surveyor to standardize the cavity preparation. Four cavities were prepared with each new bur before it was discarded, and after that, a digital caliper was used to check the dimensions of all the cavities. The samples were then assigned into three major groups in accordance with the restorative materials. (n=8), then each of subgroup was re-divided into two sub-groups (n=4) according to storage in PBS as following:

Group A1: Teeth samples were restored with Tetric PowerFill without storage (non-storage).

Group A2: Teeth samples were restored with Tetric PowerFill with storage (storage).

Group B1: Teeth samples were restored with Cention N without storage (non-storage).

Group B2: Teeth samples were restored with Cention N with storage (storage).

Group C1: Teeth samples were restored with Predicta bioactive without storage (non-storage).

Group C2: Teeth samples were restored with Predicta bioactive with storage (storage).

The materials used in this study were represented in Table (1).

Cavity restoration: The restorative procedure for each group was carried out in accordance with the manufacturer's recommendations for their restorative material. Hence for each, the cavities received etching, bonding, and restoration. The etching step was performed using phosphoric acid 37% N-etch placed for (15 sec selective etching technique for enamel) and then gently air dried after being washed. Then, G-premio bond was applied using disposable bond brush to the full cavity, wiped for 20 seconds. After that, a maximum air pressure was applied over the adhesive for approximately 5 seconds to entirely vaporize the solvent agent. Then, in accordance with the manufacturer's directions, an LED light (Valo, Ultra Dent Products Inc., USA) with an output intensity of 1000 mW/cm2 at 395-480 nm was used to cure the adhesive for 10 seconds. To provide the required proximal anatomic contour, polyvinyl siloxane matrix (3M ESPE, USA) was used for securing each tooth [17,18]. Each bulkfill composite was applied as one 4mm increment and restorations were exposed to irradiation for 20 seconds from the occlusal, buccal, and lingual surfaces, and then finished and polished using the (EVE twist system). Then, the teeth samples were then kept in the incubator for 24 hours at 37°C in distilled water.

Thermocycling procedure: All the teeth samples were subjected to 1000 thermal cycles between (5-55)°C with a dwell period of 30 second [19]. After that the teeth samples in subgroup 1 were not stored in PBS and send to FESEM/EDX analysis and the teeth samples in subgroup 2 were stored in PBS for (28 days) inside the incubator at 37°C and relative humidity at 95% then send to FESEM/EDX analysis [20].

Sectioning of the teeth: The teeth samples from each subgroup (non-storage and after storage in PBS) are subjected to longitudinal sectioning in bucco-lingual direction to the surface of acrylic and then each half sectioning horizontally below cement-enamel junction from acrylic surface by using cutting diamond wheel disc (D&Z, Germany), by this, the crown separated from the root completely and also the crown separated to mesial and distal halves. Then, the samples were cleaned in an ultrasonic water bath for 3 min, in order to remove the debris and left to dry for 24 hrs [6].

Preparation of teeth specimens for FESEM/EDX evaluation: The teeth specimens were attached to aluminum stubs using carbon double-sided tape and thin gold coating was sputtered onto the surface. The FESEM (TE SCAN MIRA3, France) that was adjusted at 20 kV accelerating voltage and 10 mA used to evaluate the marginal adaptation at the interface between the restorative materials and gingival enamel margin by

Table 1. *Materials and their compositions that used in this investigation.*

Materials	Composition
Tetric Power Fill Ivoclar viva-dent (Liechtenstein)	Monomer: UDMA, Bis-GMA, Bis-EMA, DCP propoxylated bisphenol A dimethacrylate, AFCT agent (β-allyl sulfone). Photoinitiator: CQ/amine + Ivocerin + Lucirin TPO. Filler: copolymer (Isofiller), Ba-Al-Silicate glass, mixed oxide (SiO2/ZrO2), Ytterbium trifluoride.
Cention N Ivoclar viva-dent (Liechtenstein)	Powder: Isofillers, calicium fluro-Silicate glass, Barium-aluminum-silicate glass, calicium-Barium-aluminium-fluro-Silicate glass filler, Ytterbium trifluoride, Pigment, and initiators. Liquid: PEG-400, DCP, UDMA, Aromatic aliphatic-UDMA, DMA Dimethacrylate, hydroxy peroxide, mint flavor and additives. Photoinitiator: Ivocerin, acyl phosphine oxide.
Predicta bulk bioactive Parkell (USA)	Monomer: 2-hydroxy ethyl methacrylate, 4-methyl phenylacrylate,2-propionicacid,2-methyl1,6-hexanedyl ester poly (oxy-1,2-ethanediyl), bicyclo (2,2,1) heptane. Initiator: Diphenylphosphine oxide, Di- benzoyl peroxide. Filler: nanofillers, titanium dioxide.
G-Premio BOND GC Corp. (Japan)	10-MDP, MDTP, 4-MET, thiophosphate monomer, dimethacrylate, phosphoric acid ester monomer, silicon dioxide, butylated hydroxytoluene, photoinitiator, water and acetone.
N-Etch Vivadent Ivoclar viva-dent (Liechtenstein)	37% Phosphoric-acid gel.

calculate the gap width in µm. While the elemental analysis was investigated by EDX data to calculate the weight percentages of chemical elements at the interface between the tooth specimen and restoration [21,22].

Marginal gaps calculation: Gap width is the distance from restorative material to gingival enamel at the interface and is calculated in µm. Gap width was determined by placing two points on each side of the gap (one on the restoration side and the other on the gingival enamel of the box cavity) and measuring this distance with a software program [23].

Statistical Analysis: Statistical analysis was calculated using "SPSS software" (SPSS version 20, IBM, USA). The results for the gap width analyses were analyzed by "two-way analysis of variance" (ANOVA) and "Duncan's multiple range" test at 5% significant level.

Results.

The FESEM analysis: The FESEM evaluation and the "mean and standard deviation" of gaps width in (µm) at restorative materials and gingival enamel margin interface for all groups are represented in Figure (1) and Table (2) respectively.

For the Tetric powerFill group after storage as shown in (Figure 1: A2), the gaps were noticed at the interface with the absence of any "crystal-like" structure. While in Cention N and Predicta bioactive groups after storage, although the gaps were also noticed at the interface, yet at the borders of the gaps, a crystal-like structure began to form which indicate apatite layer formation as shown in (Figure 1: B2 and C2) respectively.

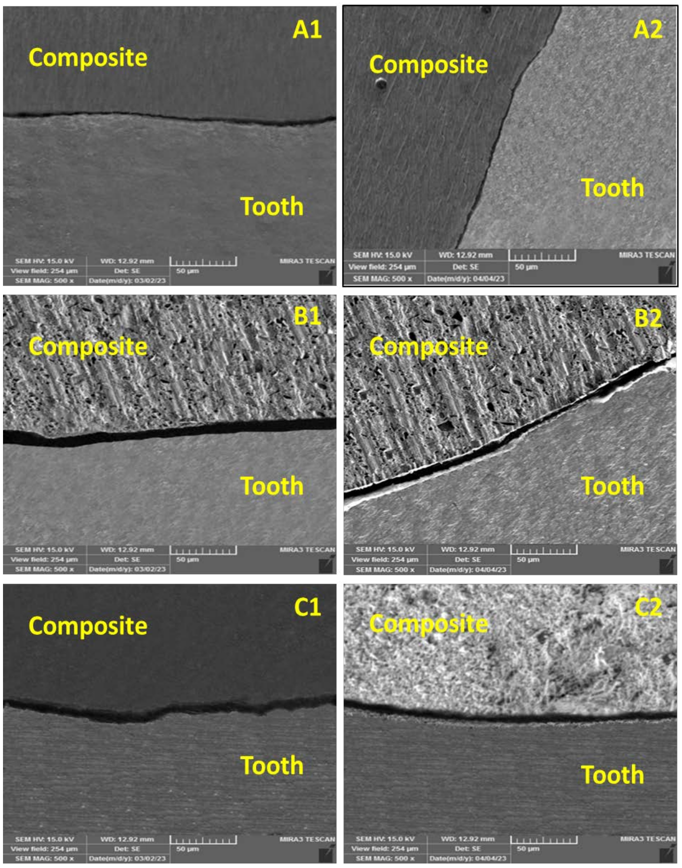

Figure 1. *Representative FESEM images of restorative materials-gingival enamel margin interface at 500x magnification; Tetric powerFill non-storage (A1) and after storage (A2); Cention N non-storage (B1) and after storage (B2); Predicta bioactive non-storage (C1) and after storage (C2).*

Table 2. *The gaps width at restorative material- gingival enamel margin interface for t materials.*

Groups	N	Mean ± SD	Minimum	Maximum
A1: Tetric powerFill non-storage	8	6.08 ± 1.36	4.33	7.64
A2: Tetric powerFill storage	8	6.50 ± 1.61	4.27	9.73
B1: Cention N non- storage	8	9.18 ± 1.02	7.68	10.88
B2: Cention N storage	8	7.66 ± 1.31	6.38	9.82
C1: Predicta bioactive non-storage	8	11.76 ± 2.07	8.52	14.42
C2: Predicta bioactive storage	8	7.49 ± 1.48	5.43	10.10
N: Eight cavities per four teeth in each group.				

Table 3. *The levels of restorative material types, storage period, and their interactions.*

Source of Variance	df	Sum of Square	Mean Square	(F)	p value
Restorative material types	2	91.067	45.533	19.850	0.0001
storage	1	38.443	38.443	16.759	0.0001
Restorative material types* storage	2	44.684	22.342	9.740	0.0001
Error	42	96.341	2.294		
Total	48	3432.443			
Corrected Total	47	270.535			

Table 4. *Test for the effect of restorative material types upon marginal fitness at restorative material-gingival enamel margin.*

Restorative material types	N	Mean ± SD	Duncan Grouping
A (Tetric powerFill)	16	6.3 ± 1.46	a
B (Cention N)	16	8.42± 1.38	b
C (Predicta bioactive)	16	9.62 ± 2.81	c
N: Sixteen cavities per eight teeth in each group.			

Table 5. *Test for the effect of storage period on gaps width at restorative material-gingival enamel margin interface.*

Storage period	N	Mean ± SD	Duncan Grouping
Non-storage	24	9.01 ± 2.79	b
Storage	24	7.22 ± 1.50	a
N: Twenty-four cavities per twelve teeth in each group.			

Two-way "ANOVA" for the effect of restorative material types, storage, and their interactions levels on the gap width formation at the interface between restorative material and gingival enamel margin as shown in Table (3) showed statistically significant difference among groups ($P \leq 0.05$).

The "Duncan's multiple range test" for the level of restorative material types regardless to storage period, and their interaction Table (4), showed that the Predicta bulk bioactive group represented statistically the highest mean of gap width (9.62 ± 2.81) in comparison to other restorative materials, while the Tetric powerFill represented statistically the lowest mean of gap width (6.3 ± 1.46).

The "Duncan's multiple range" test for the level of storage period regardless to restorative material types and their interaction Table (5), showed that the groups represented statistically the lowest gap width formation (7.22 ± 1.50) after storage in comparison to non-storage groups (9.01 ± 2.79).

Duncan's multiple range" test for the interaction of restorative materials types with storage period levels as shown in Table (6), represented that group (A1: Tetric powerFill + non-storage) and group (A2: Tetric powerFill + storage) represented statistically the lowest mean of gap width formation (6.08 ± 1.36) and (6.50 ± 1.61) respectively. Although, group (C2: Predicta bulk bioactive + non-storage) represented statistically the highest mean of gap width formation (11.76 ± 2.07) followed by group (B1: Cention N + non-storage) which register (9.18 ± 1.02) mean of gap width formation in comparison to other group. However, both groups shown statistically highly reduction in mean of gap width formation after storage in PBS with no statistically significant difference between them (p>0.05). Duncan's multiple range test for all tested groups are represented as a bar chart in Figure 2.

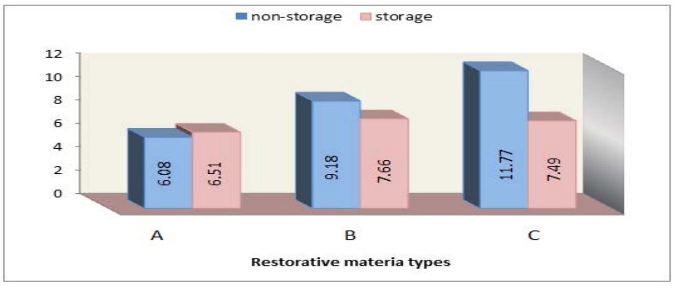

Figure 2. *Bar chart illustrated the mean gap width formation and Duncan's multiple range test for all tested groups. A (Tetric powerFill), B (Cention N), C (Predicta bioactive).*

Table 6. *Test for the interaction between restorative material and storage period levels on gaps width at restorative material-gingival enamel margin interface.*

Groups	N	Mean ± SD	Duncan Grouping
A1: Tetric powerFill non-storage	8	6.08 ± 1.36	a
A2: Tetric powerFill storage	8	6.50 ± 1.61	a
B1: Cention N non-storage	8	9.18 ± 1.02	c
B2: Cention N storage	8	7.66 ± 1.31	b
C1: Predicta bioactive non-storage	8	11.76 ± 2.07	d
C2: Predicta bioactive storage	8	7.49 ± 1.48	b
N: Eight cavities per four teeth in each group.			

Table 7. *EDX analysis of Ca, P and Ca/P ratio restorative materials after storage in PBS.*

Restorative material types	N	Ca element analysis	P element analysis	Ca/p ratio
A (Tetric powerFill)	8	1.87±0.05	0	0
B (Cention N)	8	9.83±0.02	5.31±0.02	1.8±0.005
C (Predicta bioactive)	8	9.81±0.01	5.10±0.01	1.9±0.011
N: Eight cavities per four teeth in each group.				

EDX Analysis: The EDX spectra for the elemental analysis for composite restorative materials at the interface for the non-storage and after storage in PBS for 28 days are illustrated in Figure (3). As represent for groups (A1: Tetric powerFill + non-storage) and (A2: Tetric PowerFill + storage) there was no apatite precipitation at the interface since there was no change in the elemental analysis between the two groups. While in groups (B1: Cention N + non-storage) and (B2: Cention N + storage), in addition to groups (C1: Predicta bioactive + non-storage) and (C2: Predicta bioactive + storage) since the EDX spectra registers the peak of phosphorous (P) element after storage in PBS with Ca/P ratio of about (1.8 ± 0.005) for Cention N and (1.9 ± 0.011) for Predicta bioactive, this can be indicated the precipitation of apatite and confirm the FESEM analysis that indicated the gap width reduction of both groups after storage in PBS.

The mean values of Ca, P and Ca/P ratio for the restorative materials after 28 days storage in PBS represented in Table (7).

Discussion.

Marginal adaptation and microleakage consider as an important property to determine the longevity of restorative materials of a posterior composite [3]. Although a perfect marginal closure is considered difficult to attain, clinicians should target to get fitness that are as good as possible [24]. The studies showed that a minimum gap width about 30 µm may lead to the development of a wall lesion, other studies stated that gap of about 60-70 µm ended with wall lesion and hence, predispose postoperative sensitivity and secondary caries [25-27].

The selection of gingival margin of class II box cavity as area of investigation based on the fact that the previous study stated that the most defect occur in the margin of restoration were located gingivally rather than the mesio-oclusal and the disto-oclusal margins [28,29].

Nowadays, the concept of bioactivity in dentistry, is widely expanding as the introduction of newer materials that aimed not only to replace missing tooth structure but also providing biological properties [12].

It's well known that most of studies on materials bioactivity done by preparing discs of materials by using plastic molds [12,30,31]. in the current study, the materials were placed in natural tooth structure, thus making the conditions with more simulation to clinical situation.

The null hypothesis in this investigation was rejected as the results showed a statistically significant differences in gaps width among the groups regarding the restorative material types and storage periods.

Success in restoring a class II cavity lesion, among the posterior teeth, depends on the type of dental material utilized for the restoration as well as the operator's skill [32]. In this research, Tetric powerFill composite was showed the least gaps width (with and without storage) among the other tested groups. This could be explained by the addition of co-polymers (pre-polymerized fillers) to the fillers content, which known as a special stress reliever act as "microscopic spring", allowing reliable offsetting and dropping in the stress created during the polymerization process, let down the modulus of elasticity to about (10Gp) while for standard glass filler is about (71Gp) [33,34]. In other hand, the incorporation of, Beta-allyl sulfone, which is a chain transfer addition fragmentation agent (AFCT), in the growing network lead to modulation of radical chain-

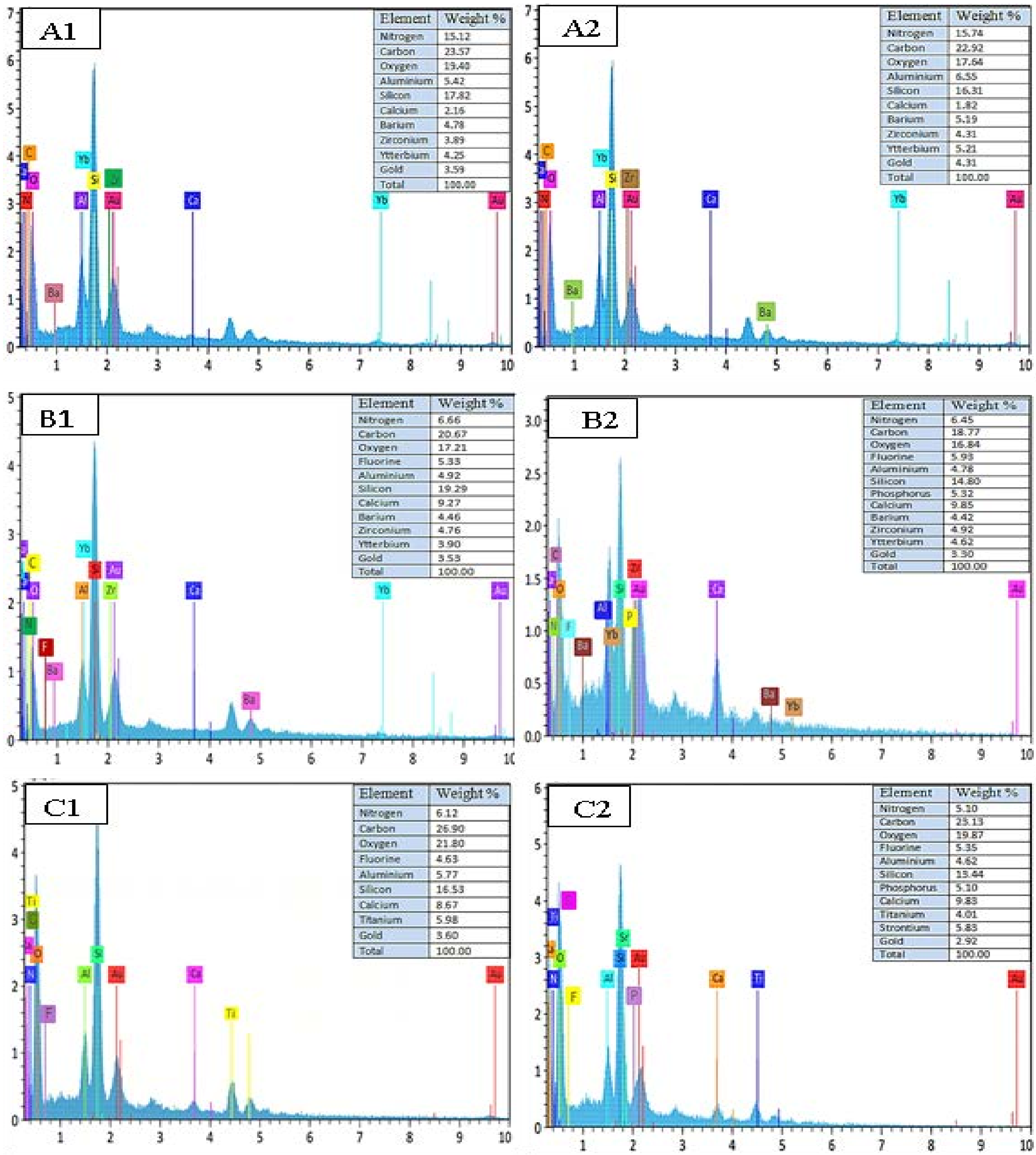

Figure 3. *The EDX spectra of Tetric powerFill non-storage (A1) and after storage (A2); Cention N non-storage (B1) and after storage (B2); Predicta bioactive non-storage (C1) and after storage (C2).*

reaction that is essentially unregulated so that it behaves more like a "step-growth polymerization" and produces a more homogenized network structure [35,36].

The gaps width for the non-storage groups showed that Cention N was higher than Tetric powerFill but lower than Predicta bulk bioactive, the reason behind that is the high molecular weight monomer "AUDMA" was added to Cention N to diminish polymerization shrinkage. Since, "AUDMA" has just two methacrylate groups and the long-chain molecule has limited mobility, leaving it difficult to bring the methacrylate groups into close physical contact. Moreover, Cention N containing the hydrophilic "PEG-400DMA" in the liquid portion that may contribute to increases flowability, thus result in stronger bonds [37-39]. Samanta et al., 2017 stated that the less microleakage in Cention N when compared with flowable composite resin and GIC, this explained by the fact that Cention N containing “Isofillers” which act as (micro-spring) that provide a cushion which restrict the polymerization shrinkage [40].

In the current study, for non-storage groups Predicta bioactive show higher gaps width than Tetric powerFill and Cention N, the fact that explains this, the low viscosity of Predicta bioactive composite (as the Predicta bioactive type used in the current study is low viscosity type as claimed by manufacture). Yet, the fillers content expected to be low and this polymerization shrinkage and its associated stress that may compromise its adaptation and sealing of the margins leading to marginal gaps and microleakage [4]. Thus, this result come in agree with Han et al., 2017 who stated that when comparing the high-viscosity bulk-fill and sonic-activated composites with low-viscosity bulkfill composites, it was shown that the latter had larger gap creation measures [24].

Bioactivity *In vitro* defined as "the ability of bioactive material to form a hydroxyapatite (HA) or apatite-like layer on its surface when it come in contact with phosphate containing fluids for 28 days". Thus, storage the specimens for 28 days was accomplished in this study [20,41]. The PBS was used as a physiological like storage solution instead of simulated body fluid since it is free from Ca^{++} ion. It consists of the following composition in (Mm): KCl (2.7), NaCl (137), KH_2PO_4 (1.8), Na_2HPO_4 (10), with (PH=7.4) [12].

After storage for 28 days in PBS, Cention N was showed reduction in gaps width but less than Predicta bioactive, this may be explained by the fact that in the current study Cention N was used in light-curing mode rather than self-curing mode, as self-cure polymerization lead to lower degree of conversion and subsequently higher solubility and ion release. Indeed, the photo-polymerization procedure lead to formation of tightly bond matrix with less hydrophilicity, Hence, there is a decline in ions releasing capacity [42].

Another possible explanation is that the Cention N in current study was applied in combination with bonding agent, according to Abdallah., 2022 who study the interaction that happen at the interfacial contact between Cention N and tooth structure stated that the use of adhesive in combination with Cention N lead to insignificant increase in Ca and p ions, this may be due to the reduction in the diffusion of these ions into tooth structure by forming a hybrid layer which confirmed by SEM image [22,39]

While for Predicta bioactive, the storage result in statistically significant reduction in gaps width this may explained considering the ability of Predicta bioactive to release calcium and phosphate ions that can encourage the remineralization and mineral apatite creation at the interface between the tooth and material. In the field, such bioactivity can be translated to stronger contacts and sealing of margins against infiltration [43]. From other side, the Predicta bulk bioactive, one of its compositions as manufacture claimed is HEMA, which is hydrophilic monomer with higher solubility, this may explained its ability to more ions release and more enhancing in its bioactivity [44].

The presence of TiO_2 in the component of Predicta bioactive as claimed by manufacturer and confirmed by EDX analysis, may enhance the bioactivity and HA formation of this material. Liang et al., 2006 stated that the TiO_2 nanocomposites show a much higher binding capacity for phosphate groups [45]. Indeed, the HA formation is a chemical process that need several conditions. Firstly, the negative charge surface (as TiO_2 have negative charge in high pH), actually the negative charge result in Ca ions attraction to the surface with over saturated solution which in turn result in, HA development [46]. Secondly, at a PH between 4.2 and 12, HA is the utmost constant compound in the calcium phosphate system. Hence, the current storage solution was PBS of (PH=7.4), for this reason, it was a proper solution for apatite precipitation [47,48].

The EDX of Predicta bulk bioactive shows the presence of strontium (Sr). It well known that (Sr) used in dental material to provide radiopacity, but some studies reported that the combined effect of Sr and even low amount of F in bioactive materials enhance the apatite precipitation and bioactivity. Indeed, Sr is a divalent cation that is located in the same column of calcium in the elements periodic. Hence, Strontium possesses chemical properties that are somewhat comparable to those of calcium so, it can partially replace calcium and be integrated into the crystal lattice of hydroxyapatite to produce (Sr-hydroxyapatite), which has strong bioactivity and can directly attach to tissue [49,50].

A study conducted by Odermatt et al., 2020 showed that the addition of nano-sized, micro-sized and hybrid bioactive glass fillers to composite resin and after immersion in PBS for 28 days, among other types of fillers, the nano-sized fillers appeared to have faster elevation in PH with improving ions release and hydroxyl apatite precipitation, this result was expected as the nano-sized fillers have about 30 times more specific area for ions exchange [12]. Actually, this finding is in accordance with the current study as Predicta bioactive composite with nano-sized fillers provide more bioactivity when compared to Cention N with micro-sized fillers.

A study provides by Jefferies et al., 2015 indicated that each bioactive substance has a unique rate of apatite precipitation, they found in their study that the time needed for apatite formation to complete closure the artificial marginal gaps is about 8 months in calcium based bioactive cement after immersion in PBS [51]. Hence, the storage period in current study may consider short for complete gaps closure.

The Predicta bioactive composite, a novel material with unknown physical and chemical properties, is the limitation of the current in vitro study; therefore, additional research is required.

Conclusion.

With the limitation of current study, It is possible to deduce that marginal fitness can be influenced by various restorative material types that were used. The Tetric powerFill composite (non-storage) represented statistically the lowest gap width formation, while the Predicta bioactive (non-storage) represented statistically the highest gap width formation. Bioactive restorative materials showed statistically significant reduction in gaps width after storage in PBS. Both Cention N and Predicta bioactive are promising bioactive restorations with potential clinical benefits.

Conflicts of Interests.

There was not detected any potential conflict of interest pertaining to this article.

Acknowledgments.

This work was reinforced by the College of Dentistry, University of Mousl.

REFERENCES

1. Hayashi J, Espigares J, Takagaki T, et al. Real-time in-depth imagining of gap formation in bulk-fill resin composites. Dent Mater. 2019;4:585-96.
2. Owens BM, Phenbus JG, Johnson WW. Evaluation of the marginal integrity of bioactive restorative material. Gen Dent. 2018;66:32-36.
3. Park KJ, Pfeffer M, Näke T, et al. Evaluation of low-viscosity bulk-fill composites regarding marginal and internal adaptation. Odont. 2021;109:139-148.
4. Ferracane JL, Lawson NC. Probing the hierarchy of evidence to identify the best strategy for placing class II dental composite restorations using current materials. J Esthet Restor Dent. 2021;33:39-50.
5. Fronza BM, Rueggeberg FA, Braga RR, et al. Monomer conversion, microhardness, internal marginal adaptation, and shrinkage stress of bulk-fill resin composites. Dent Mater. 2015;31:1542-1551.
6. Chisnoiu AM, Moldovan M, Sarosi C, et al. Marginal adaptation assessment for two composite layering techniques using dye penetration, AFM, SEM and FTIR: An in-vitro comparative study. Appl Sci (Switzerland). 2021;11:1-14.
7. Sampaio CS, Arias FJ, Atria JP, et al. Volumetric polymerization shrinkage and its comparison to internal adaptation in bulk-fill and conventional composites: A μCT and OCT in vitro analysis. Dent Mater. 2019;35:1568-1575.
8. Assiri A, Alomairy A, Nashaat M. Marginal Adaptation of Bulk-Fill versus Layered Resin Composite Restorations. Inter J Health Sci Res. 2018;8:65-74.
9. Leprince J, Palin W, Vanacker J, et al. Physio-mechanical characteristics of commercially available bulk-fill composites. J Dent. 2014;24:993-1000.
10. Yap AU, Eweis AH, Yahya NA. Dynamic viscoelastic characterization of bulkfill resin-based composites and their conventional counterparts. Operat Dent. 2020;45:173-182.
11. Zhang K, Zhang N, Weir MD, et al. Bioactive dental composites and bonding agents having remineralizing and antibacterial characteristic. HHS Public Access. 2018;61:669-687.
12. Odermatt R, Par M, Mohn D, et al. Bioactivity and physico-chemical properties of dental composites functionalized with nano-vs. Micro-sized bioactive glass. J Clin Med. 2020;9:1-13.
13. ISO/ TS 11405: Dentistry_ Testing of adhesion to tooth structure. 3rd ed. Geneva: International Organization for Standarization; 2015.
14. Kaisarly D, El Gezawi M, Nyamaa I, et al. Effects of boundary condition on shrinkage vectors of a flowable composite in experimental cavity models made of dental substrate. Clin Oral Invest. 2019;23:2403-2411.
15. Turkistani A, Nasir A, Merdad Y, et al. Evaluation of microleakage in class-II bulk-fill composite restorations. J Dent Scien. 2020;15:486-492.
16. Sardana A, Kumar M, Taneja S. Comparative evaluation of microleakage and hardness of newer posterior restorative materials. J Oral Bio Cranio Res. 2022;12:733-736.
17. Shahidi C, Krejci I, Dietschi D. In vitro evaluation of marginal adaptation of direct class II composite restorations made of different "low-shrinkage" systems. Oper Dent. 2017;42:273-83.
18. Rizzante F, Sedky R, Furus A, et al. Validation of a method of quantifying 3D leakage in dental restorations. J Prosth Dent. 2020;123:839-844.
19. Zavattini A, Mancini M, Higginson J, et al. Micro-computed tomography evaluation of microleakage of class II composite restoration: An in vitro study. Europ J Dent. 2018;12:369-374.
20. Benett AR, Michou S, Larsen L, et al. Adhesion and marginal adaptation of a claimed bioactive, restorative material. Biomater Invest in Den. 2019;6:90-98.
21. Tosco V, Vitiello F, Furlani M, et al. Microleakage Analysis of Different Bulk-Filling Techniques for Class II Restorations: µ-CT, SEM and EDS Evaluations. Materials. 2021;14:1-13.
22. Abdallah A. Elemental and Micromorphological Analysis of New Alkasite Based Restorative Material/Tooth Interface. EDJ. 2022;68:1065-1072.
23. Darabi F, Tayefeh-Davalloo R, Tavangar SM, et al. The effect of composite resin preheating on marginal adaptation of class II restorations. J Clin Exper Dent. 2020;12:e682-e687.
24. Han SH, Park SH. Comparison of internal adaptation in class II bulk- fill composite restorations using micro-CT. Oper Dent. 2017;42:203-14.
25. Maske TT, Hollanders AC, Kuper NK, et al. A threshold gap size for in situ secondary caries lesion development. J Dent. 2019;80:36-40.
26. Kuper N, Opdam N, Ruben J, et al. Gap size and wall lesion development next to composite. J Dent Res. 2014;93:108S-113S.
27. Sampaio CS, Garcés GA, Kolakarnprasert N, et al. External marginal gap evaluation of different resin-filling techniques for class II Restorations—A micro-CT and SEM Analysis. Oper Dent. 2020;45:E167-E175.
28. Hirata R, Pacheco RR, Caceres E, et al. Effect of sonic resin composite delivery on void formation assessed by micro-computed tomography. Oper Dent. 2018;43:144-150.
29. Díaz CAP, Shimokawa C, Sampaio CS, et al. Characterization and comparative analysis of voids in class II composite resin restorations by optical coherence tomography. Oper Dent. 2020;45:71-79.
30. Kasraei S, Haghi S, Valizadeh S, et al. Phosphate Ion Release and Alkalizing Potential of Three Bioactive Dental Materials in Comparison with Composite Resin. Int J Dent. 2021;30:1-8.
31. Pokharkar PM, Hadakar S, Taur S, et al. Comparative evaluation of bioactivity of Cention N incorporated with inorganic nanoparticle: A scanning electron microscope–energy-dispersive X-ray spectroscope analysis. J Int Clin Dent Res Organ. 2023;15:50-4.
32. Tosco V, Vitiello F, Furlani M, et al. Microleakage analysis of different bulk-filling techniques for class II restorations: µ-CT, SEM and EDS evaluations. Mater. 2020;14:1-8.

33. Haidy NS, Sherif M, Hefnawy, et al. Degree of conversion and polymerization shrinkage of low shrinkage bulk fill resin composites. Contemp Clin Dent. 2019;10:465-470.
34. Negovetic Mandic V, Par M, Marovic D, et al. Blue Laser for Polymerization of Bulk-Fill Composites: Influence on Polymerization Kinetics. Nanomaterials. 2023;13:1-12.
35. Hayashi J, Tagami J, Chan D, et al. New bulk-fill composite system with high irradiance light polymerization: Integrity and degree of conversion. Dent Mater. 2020;36:1615-1623.
36. Watts DC, Algamaiah H. Characterizing surface viscoelastic integrity of ultra-fast photo-polymerized composites: Methods development. Dentl Mater. 2020;36:1255-1265.
37. Batra D, Kaur M, Singh Mann N, et al. A comparative evaluation of compressive strength of Cention N with glass Ionomer cement: An in-vitro study. Int J Appl Dent Sci. 2019;5:5-9.
38. Adsul PS, Dhawan P, Tuli A, et al. Evaluation and Comparison of Physical Properties of Cention N with Other Restorative Materials in Artificial Saliva: An In Vitro Study. Int J Clin Ped Dent. 2022;15:350-355.
39. Tod JC. Scientific documentation: Cention N. Ivoclar-Vivadent Press: Schaan, Liechtenstein. 2016:1-5.
40. Samanta S, Das UK, Mitra A. Comparison of microleakage in Class V cavity restored with flowable composite resin, glass ionomer cement and Cention N. Imp J Interdiscip Res. 2017;3:180-183.
41. Spagnuolo G. Bioactive Dental Materials: The Current Status. Mater. 2022;15:1-3.
42. Gupta N, Jaiswal S, Nikhil V, et al. Comparison of fluoride ion release and alkalizing potential of a new bulk-fill alkasite. J Conserv Dent. 2019;22:296-299.
43. Jumaah SS, Al-Shamma AM. Immediate and Long Term Gingival Marginal Leakage of Two Bioactive Bulk Fill Restorative Materials (A Comparative in vitro Study). J Res Med Dent Sci. 2021;9:120-126.
44. Tiskaya M, Al-Eesa NA, Wong FSL, et al. "Characterization of the bioactivity of two commercial composites". Dent Mater. 2019;35:1757-1768.
45. Liang S, Makamba H, Huang S, et al. Nano-titanium dioxide composites for the enrichment of phosphopeptides. J Chromatogr A. 2006;1116:38-45.
46. Kim HM, Himeno T, Kokubo T, et al. Process and kinetics of bonelike apatite formation on sintered hydroxyapatite in a simulated body fluid. Bio mater. 2005;26:4366-73.
47. Aljabo A, Neel EAA, Knowles JC, et al. Development of dental composites with reactive fillers that promote precipitation of antibacterial-hydroxy- apatite layers. Mater Sci Engin. 2016;60:285-292.
48. Fahmy MM, Moussa TM, Abdelraouf RM. Evaluation of ion release, apatite formation and tooth-restoration interface of bioactive resin composite versus conventional resin composite (an in vitro study). EDJ. 2021;67:1463-1473.
49. Hassan U, Farooq I, Mahdi S, et al. Newer Glass Ionomer Cement having Strontium Ions and the Effect of their Release on Acidic Medium International. J Prosth Res Dent. 2012;2:57-60.
50. Dai LL, Nudelman F, Chu CH, et al. The effects of strontium-doped bioactive glass and fluoride on hydroxyapatite crystallization. J Dent. 2021;105.
51. Jefferies SR, Fuller AE, Boston DW. Preliminary evidence that bioactive cements occlude artificial marginal gaps. J Esth Rest Dent. 2015;27:155-16.