IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 6 Ser. 11 (June. 2024), PP 16-21
www.iosrjournals.org

Addition Of Gouramy Fish Scales Powder To Shear Bond Strength And Surface Roughness Of Glass Ionomer Cement

Ericha Dwi Kurniasari Sulaiman[1], Ni Made Widiastuti[1],
I Dewa Ayu Ratna Dewanti[2], Erawati Wulandari[3*], Agus Sumono[4]
Student Of Faculty Of Dentistry, Jember University, Jember - Indonesia
Department Of Biomedical Dentistry, Faculty Of Dentistry, Jember University, Jember – Indonesia
Department Of Conservative Dentistry, Faculty Of Dentistry, Jember University, Jember – Indonesia
Department Of Dental Biomaterials, Faculty Of Dentistry, Jember University, Jember – Indonesia

Abstract
Low shear bond strength and rough surface are disadvantages of glass ionomer cement (GIC) restorative materials. Low shear bond strength causes the formation of gaps at the edges of the restoration due to failure of the bond between the restorative material and the tooth tissue, while surface roughness can accelerate bacterial colonization and maturation of dental plaque. Gouramy scale (Osphronemus gouramy) contain hydroxyapatite (HA) which can improve the physical and mechanical properties of GIC. This study aims to determine the effect of the addition of Gourami Fish Scales Powder (GFSP) on the shear bond strength and surface roughness of the GIC. The research sample was divided into five groups, namely G0 (GIC) as the control group, G1 (GIC + 0.5% GFSP), G2 (GIC + 1.5% GFSP), G3 (GIC + 2.5% GFSP) and G4 (GIC + 3.5% GFSP). The sample for the shear bond test was the permanent maxillary first premolar which was placed on the dentin layer using GIC with a diameter of 3 mm and a height of 3 mm, then measured using a Universal Testing Machine. The sample for the surface roughness test was in the form of a tablet with a diameter of 5 mm and a height of 2 mm, then measured using a surface roughness tester. Shear bond strength data were analyzed using One Way Anova and LSD test. Surface roughness data were analyzed using Kruskall Wallis and Mann Whitney. The average value of the lowest to the highest shear bond strength is G0 < G1 < G2 < G3 < G4 and the surface roughness is G4 < G3 < G2 < G1 < G0. The conclusion of this study is that the addition of GFSP with concentrations of 0.5%, 1.5%, 2.5% and 3.5% increased the shear bond strength and decreased the surface roughness of the GIC.
Keywords: *glass ionomer cement, gouramy fish scale powder, shear bond strength, surface roughness.*

Date of Submission: 19-06-2024 Date of Acceptance: 29-06-2024

I. Introduction

Conventional GIC is often used in dentistry as a restorative material because it has advantages such as biocompatible with pulp tissue, tooth-colored restorative material, binds well to tooth structure, and releases fluoride as an anti-cariogenic [1]. However, it has disadvantages, namely low fracture and wear resistance, sensitivity to moisture, and porosity [2]. Porosity in the GIC microstructure can affect the occurrence of surface roughness and reduce the shear bond strength between the GIC and the tooth structure [3]. If the shear bond strength is low, then the restoration edge may leak due to failure of the bond between the restorative material and the tooth tissue [4]. Restoration surfaces with high roughness can make it easier for bacteria to adhere and cause the formation of biofilms on teeth and restorative materials relatively quickly [5] , thereby potentially increasing the risk of oral disease, causing gingival irritation, and reducing aesthetics [1].

Efforts to improve the physical and mechanical properties of GIC include reducing surface roughness and increasing shear bond strength, one of which is the addition of hydroxyapatite [6]. Hydroxyapatite (HA) with nanoparticle size has a crystal structure similar to dental apatite and has been shown to increase remineralization and reduce microleakage of restorative materials [7]. Nanoparticle Hydroxyapatite (NHA) are perfectly adsorbed in the GIC matrix and increase the formation of salt bridges thereby improving the mechanical and physical properties of GIC [8]. One of the natural ingredients that contain HA and is used to improve the physical and mechanical properties of GIC is gouramy (*Osphronemus gouramy*) fish scales. Gouramy scales contain mineralization in the form of HA with a concentration of 16% to 59% [9].

Previous research regarding the addition of GFSP in GIC with concentrations of 2.5%, 5% and 10%, the results showed that the number and diameter of the porosity were the smallest, the marginal gap was the smallest and the compressive strength was the biggest in the GIC with the addition of 2.5% gourami fish scale powder [10,11]. The GFSP added in that study was not in nanoparticle size, which was 74 µm, while the GIC powder have a size of 10 µm. This causes the GFSP not to be well adsorbed in the GIC powder and lowers the adhesion strength between the powder mixtures [12]. The bigger concentration of GFSP added, the more GFSP substitution in GIC will be and cause no optimal cross-linking in GIC [13], resulting in GIC with poor mechanical strength due to the addition of large GFSP particle size.

This study added GFSP nanoparticles to conventional GIC restoration materials to increase the shear bond strength and decrease the surface roughness of conventional GIC with GFSP concentrations of 0.5%, 1.5%, 2.5%, and 3.5%.

II. Materials And Methods

Making Gouramy Fish Scale Powder

The gouramy scales were dried by freeze drying method using a freeze dryer (Virtiz Freezemobile 25 XL, New York, USA) then the fish scales were mashed with a blender (Cosmos, Jakarta, Indonesia) and sieved using a 200 mesh sieve (ABM Test Sieve Analysis, Jakarta, Indonesia) [14]. The sifted fish scale powder was then carried out with a ball milling process and sieved again with a 200 mesh sieve [15]. Furthermore, the degree of acidity of GFSP was tested and obtained a pH of 7.82, which means that GFSP is classified as alkaline or base. The particle size of GFSP was analyzed using a Particle Size Analyzer (Horiba-SZ 100z, California, US) and obtained a particle size of 51.77 nm.

Sample Group

The sample group in the shear bond strength test and surface roughness test were divided into five groups: G0 (GIC) as the control group, G1 (GIC + 0.5% GFSP), G2 (GIC + 1.5% GFSP), G3 (GIC + 2.5% GFSP) and G4 (GIC + 3.5% GFSP). GIC powder (GC Fuji 9 Gold Label High Strength Posterior Extra, Japan) and GFSP were mixed using a vortex (Labinco L46, Breda, Netherland).

Preparing Teeth for the Shear Bond Strength Test

The maxillary permanent first premolar tooth with complete maturation, free of caries, fracture, and restoration was separated from the crown and root using a carborundum disc (Azdent, Zhengzhou, China). The crown of the tooth was split into two halves parallel to the long axis of the tooth (long axis) in a buco-palatal direction, thus obtaining two dental specimens, the mesial and distal parts. The outer mesial and distal surfaces were honed using a carborundum disc (Azdent, Zhengzhou, China) to reveal a layer of dentin with a flat area of 4-5 mm and then smoothed using 600-grit silicon carbide paper (GCP, Jakarta, Indonesia) for 15 seconds under water. flow to equalize the amount of dentin surface being sharpened [16,17,18,19].

Self cured acrylic resin powder and liquid (Mr.Cure, Bandung, Indonesia) were manipulated and poured into a 2 x 2 cm diameter PVC pipe (Maspion, Surabaya, Indonesia) to the brim. The tooth specimen was immediately immersed in self-cured acrylic resin before hardening in a horizontal position, so that the sharpened tooth surface was facing upwards. This step is carried out carefully so that the dentin area on the surface of the sharpened tooth is not contaminated by acrylic resin. After hardening, the acrylic resin is removed from the PVC pipe to obtain a cylindrical acrylic resin [16,18].

Sample Making

In the sample for the shear bond strength test, the dentin surface was smeared with dentin conditioner (GC, Tokyo, Japan) for 20 seconds using a microbrush (GC, Tokyo, Japan) and rinsed using distilled water (Aquades, Surabaya, Indonesia) for 15 seconds and then dried using chip blower (Dental Blower, Mumbai, India) with light pressure to obtain a moist dentin surface [17.5]. The hole in the split Teflon mold (Split Teflon, Jember, Indonesia) was placed above the dentin surface [16]. Powder (each group) and GIC liquid (GC Fuji 9 Gold Label High Strength Posterior Extra, Japan) with a ratio of 3.4:1 were manipulated on a paperpad (GC, Tokyo, Japan) for 25 seconds [20], then put into split Teflon mold until full [10], then condensed using a cement stopper (Schezher, Berlin, Germany) [1]. Samples for the surface roughness test were made by manipulating GIC powder and liquid and then put into an acrylic mold (Raya Printing, Jember, Indonesia) and condensed [1]. The next step is the same as sample preparation for the shear bond test. The top surface of the sample was covered with a celluloid strip (Tor VM Transparent Striproll, Moscow, Russia), then loaded with 0.5 kg for 20 seconds. The sample was left in the mold and put in a closed container (Onyx, Jakarta, Indonesia) for 24 hours [1]. After 24 hours the sample was removed from the mold, put in a closed container and given aquadest until the sample was submerged, then put into an incubator (Biobase BJPX-H123II, Karnataka, India) 37ºC for 24 hours [21]. The samples were dried on all surfaces using water spray (Spray Nozzels, Tokyo, Japan) for 20 seconds [22], then the samples were stored in plastic clips (KP Klip, Tangerang, Indonesia) for 24 hours and then tested.

Shear Bond Strength Test

Shear bond strength test using Universal Testing Machine (HungTa, Xiamen, China) [19]. The sample was positioned horizontally on a tray on the test apparatus with the blade positioned in the sample attachment area and the dentin at a crosshead speed of 0.5 mm/min until the sample fractured and detached from the tooth surface. The results of the shear bond strength test will appear on the monitor screen in MPa unit. The greater shear bond strength implies better bonding of the restorative material to the tooth surface [24, 16, 17].

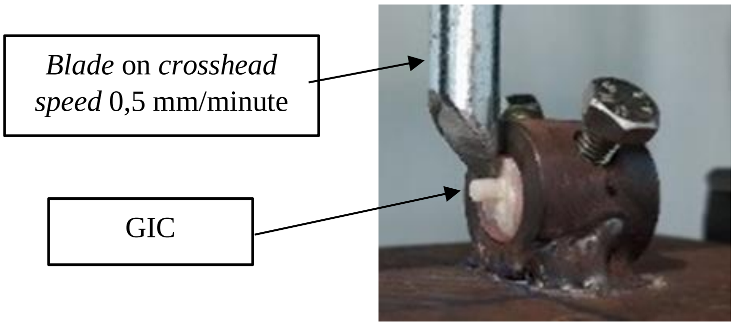

Figure 1. Shear Bond Strength Test

Surface Roughness Test

Surface roughness test used a surface roughness tester (Roughness Tester TR 220, Dongguan, China) [23]. Surface roughness measurements were carried out on three measurement lines for each sample and then the average was calculated. The sample is placed on a flat surface and the stylus on the surface roughness tester is placed parallel to the sample measurement line. The tool is activated and the stylus moves along a straight line along the surface. The monitor on the test equipment will show the roughness value in μm unit [1, 23].

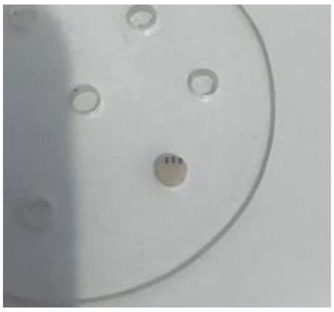

Figure 2. Three measurement lines on the top surface of the sample

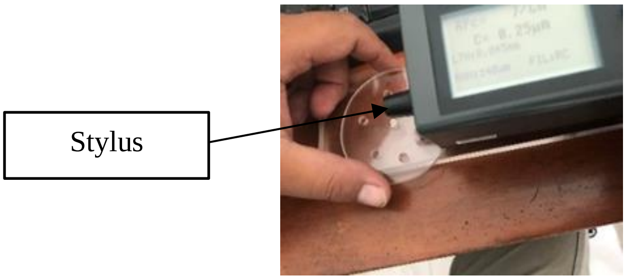

Figure 3. The stylus (which is indicated by the arrow) on the Surface Roughness Tester is placed parallel to the sample measurement line

III. Results

The average value of the shear bond strength and surface roughness of GIC is shown in Table 1 and Figure 3. The average value of the lowest to the highest shear bond strength is G0 < G1 < G2 < G3 < G4 and the surface roughness is G4 < G3 < G2 < G1 < G0.

Table 1. The average value of the shear bond strength and surface roughness of GIC and GIC with the addition of GFSP

Groups	Shear Bond Strength (MPa)	Roughness Surface (µm)
G0 (GIC)	4,43 ± 0,44	0,66 ± 0,10
G1 (GIC + 0,5% GFSP)	4,59 ± 0,46	0,46 ± 0,04
G2 (GIC + 1,5% GFSP)	4,78 ± 0,36	0,40 ± 0,02
G3 (GIC + 2,5 % GFSP)	4,92 ± 0,32	0,33 ± 0,01
G4 (GIC + 3,5% GFSP)	5,27 ± 0,31	0,22 ± 0,07

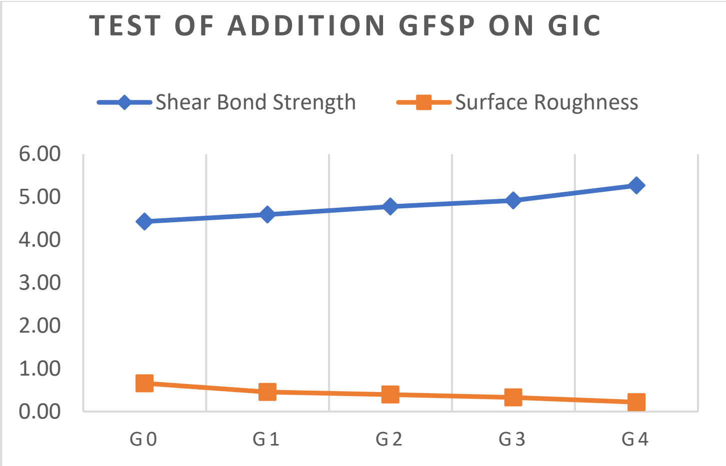

Figure 4. Shear bond strength and surface roughness

The results of the Shapiro-Wilk and Levene test on the shear bond strength test showed that the data were normally distributed and homogeneous ($p>0.05$). The ANOVA test showed that the value of $p=0.025$ ($p<0.05$) meant that the average value of the shear bond strength in each group had a significant difference. The results of the LSD test showed that the shear bond strength was significantly different between G0 and G3; G1 and G3.

The results of the Shapiro-Wilk and Levene test on the surface roughness test showed that the data were normally distributed ($p>0.05$) and not homogeneous ($p<0.05$). The Kruskal Wallis test showed that the value of $p = 0.000$ ($p <0.05$) means that the average value of the surface roughness in each group has a significant difference. The results of the Mann Whitney test showed that the surface roughness was significantly different in all groups.

IV. Discussion

The shear bond strength of GIC is related to the principle of adhesion which is considered important to maintain its attachment to the dental tissue [25]. The adhesion bond between GIC and the dentinal structure is more difficult to obtain due to its heterogeneous, dynamic, vital, and hydration properties because the mineral components contained in dentin are less than in enamel [4].

Surface roughness is a form of irregularity of the surface of a material [1]. Restoration surfaces with high roughness can make it easier for bacteria to adhere and cause the formation of biofilms on teeth and restorative materials relatively quickly [5], thus potentially increasing the risk of oral disease, causing gingival irritation, and reducing aesthetics [1].

The results showed that the GIC sample group with the addition of GFSP nanoparticles (G1, G2, G3 and G4) had a higher shear bond strength and lower surface roughness compared to the GIC sample group without the addition of GFSP (G0). When GIC and GFSP powders containing hydroxyapatite are mixed with GIC liquid, Ca^{2+} ions will be released from the GFSP hydroxyapatite and act as additional calcium to initiate the reaction with polyacrylic acid in the GIC liquid [26]. Hydroxyapatite from GFSP will fill the gap between the glass particles in the GIC, so that more cross linking is formed, increasing the GIC density and preventing the formation of pores. The absence of pores will create a strong shear bond strength and low surface roughness (smooth surface) [27]. The denser GIC will increase its mechanical strength so as to increase its ability to resist wear and not break easily [28].

The higher the concentration of GFSP added to the GIC, the higher the shear bond strength and the lower the surface roughness. This is presumably due to an increase in the concentration of HA GFSP in GIC powder. The higher the concentration of HA, the more calcium binds to the polyacrylic acid in the GIC fluid, resulting in an increase in the degree of acid-base reaction in the GIC structure. An increase in the degree of acid-base reaction will cause an increase in cross-linking in the GIC thereby increasing the density and strength of the GIC and preventing the formation of pores [27,13].

The GIC setting reaction is an acid-base reaction between polyacrylic acid liquid as a proton donor (acidic) and aluminosilicate glass on a powder as a proton acceptor (basic) [29]. The pH test results showed that the gouramy scale powder had a pH of 7.82, so that the gouramy scale powder was included in the alkaline or base category. The degree of acidity (pH) of the base of the gouramy scale powder causes the gourami scale powder which is added to the GIC powder capable of reacting acid-base with the GIC liquid.

The particle size of GFSP is 51.77 nm (nanoparticles). Nanoparticles are small particle sizes that have a larger contact surface area, so that it will increase the adhesion force between the particles of a mixture of gouramy fish scale powder and GIC powder [12]. Thus the GFSP nanoparticles will be perfectly embedded in the GIC matrix so that the GFSP fills the distance between the glass particles in the GIC, forming a denser GIC and minimizing the formation of porosity [8,27]. Porosity affects the strength and durability of a restorative material [28]. The absence of porosity will create a higher shear bond strength and create a low surface roughness (smooth surface) [27].

The high shear bond strength of restorative materials implies a good adhesion (retention) bond between the GIC material and the tooth surface [17]. Adhesion between GIC and tooth structure occurs when ions in GIC penetrate the HA surface of the dentinal tissue and then fuse to form an ion exchange layer containing ions from GIC ($[SiO_2]$, $[Al^{3+}]$, $[F^-]$, $[Sr^{2+}]$, $[Ca^{2+}]$) and dentinal tissue HA ions ($[PO_4^{3-}]$ and $[Ca^{2+}]$) [29]. The more additional Ca^{2+} from HA GFSP, the stronger the adhesion bond between the GIC molecules and the dental tissue [27].

The acceptable surface roughness of a restorative material is equal to or less than the enamel roughness at the occlusal contact area, which is 0.64 ± 0.25 µm [30]. The GFSP addition group (G1, G2, G3 and G4) had an average surface roughness value of less than 0.64 µm, meaning that each sample group added with GFSP nanoparticles had a low surface roughness (smooth surface) and was still clinically acceptable.

V. Conclusion

The addition of GFSP with concentrations of 0.5%, 1.5%, 2.5% and 3.5% increased the shear bond strength and decreased the surface roughness of GIC, where the best results were at a concentration of 3.5%.

Acknowledgements

Thank you to all laboratory technicians who have given us permission and facilities to use all the tools in this research. We declare that there was no conflict of interest before, during, or after this research.

References

[1] Diansari V., Ningsih D.N., Moulinda C., Evaluasi Kekasaran Permukaan Glass Ionomer Cement (Gic) Konvensional Setelah Perendaman Dalam Minuman Berkarbonasi, Cakradonya Dental Journal, 8(2), 111-116 (2016).

[2] Chen S., Cai Y., Engqvist H., Enhanced Bioactivity Of Glass Ionomer Cement By Incorporating Calcium Silicates, Biomatter Journal, 6(1), 1-7 (2016).

[3] Rodrigues D.S., Buciumeanu M., Martinelli A.E., Nascimento R.M., Henriques B., Silva F.S., Mechanical Strength And Wear Of Dental Glass-Ionomer And Resin Composites Affected By Porosity And Chemical Composition, J Bio- Tribo-Corrosion, 1(3), 1–9 (2015).

[4] Fibryanto E., Bahan Adhesif Restorasi Resin Komposit, Jurnal Kedokteran Gigi Terpadu, 2(1), 8-12 (2020).

[5] Arba K.F., Fatmawati D.W.A., Lestari S., Effect Of Horizontal Tooth Brushing Methods To The Surface Roughness Of Ncr, Gic, And Rmgic In Class V Cavities, Journal Of Indonesian Dental Association, 4(1), 35-40 (2021).

[6] Khaghani M., Doostmohammadi A., Alizadeh S., Investigation The Compressive Strength Of Glass Ionomer Cement Containing Hydroxyapatite Nano And Micro Particles, Austin Journal Of Biotechnology & Bioengineering, 3(3), 1068 (2016).

[7] Poorzandpoush K., Omrani L.R. , Jafarnia S.H., Golkar P., Atai M., Effect Of Addition Of Nano Hydroxyapatite Particles On Wear Of Resin Modified Glass Ionomer By Tooth Brushing Simulation, Journal Of Clinical And Experimental Dentistry, 9(3), 372-376 (2017).

[8] Shiekh R.A., Rahman I., Masudi S.M., Luddin N., Modification Of Glass Ionomer Cement By Incorporating Hydroxyapatite-Silica Nano-Powder Composite: Sol–Gel Synthesis And Characterization, Ceramics International, 40(2), 3165-3170 (2014).

[9] Dewanti I.D.A.R., Lestari P.E., Purwanto P., Wulandari E., Widhi R., Wibisono S., Burlakovs J., Bones, Scales Of Upeneus Sulphureus And Osphronemus Gouramy Increase Adhesion And Decrease Il-1β Expression On Monocytes Against Streptococcus Mutans, Annals Of Tropical Medicine & Public Health, 23(8), 1253-1258 (2020).

[10] Wulandari E., Wardani F.R.A., Fatimattuzahro N., Dewanti I.D.A.R., Addition Of Gourami (Osphronemus Gouramy) Fish Scale Powder On Porosity Of Glass Ionomer Cement, Dental Journal-Majalah Kedokteran Gigi, 55(1), 33-37 (2022).

[11] Dewanti I.D.A.R., Firdausya D.A., Mantika S.I., Amalia A.F., Rifqoh Z.T., Wulandari E., Marginal Gap, Compressive Strength And Bacterial Inhibition Of Gurami Fish (Osphronemus Gouramy) Scales Powder, Iosr Journal Of Dental And Medical Sciences, 1(1), 53-59 (2022).

[12] Alobiedy A.N., Al-Helli A.H., Al-Hamaoy A.R., Effect Of Adding Micro And Nano-Carbon Particles On Conventional Glass Ionomer Cement Mechanical Properties, Ain Shams Engineering Journal, 2019, 1-5 (2019).

[13] Barandehfard F., The Addition Of Synthesized Hydroxyapatite And Fluorapatite Nanoparticles To A Glass Ionomer Ceent For Dental Restoration And Its Effects On Mechanical Properties, Journal Ceramint, 42(15), 70-75 (2016).

[14] Ifa L., Artiningsih A., Julniar, Suhaldin, Pembuatan Kitosan Dari Sisik Ikan Kakap Merah, Journal Of Chemical Process Engineering, 3(1), 47-50 (2018).

[15] Mawadara P.A., Mozartha M., Trisnawaty K., Pengaruh Penambahan Hidroksiapatit Dari Cangkang Telur Ayam Terhadap Kekerasan Permukaan Gic, Jurnal Material Kedokteran Gigi, 2(5), 8-14 (2016).
[16] Shebl E.A., Etman W.M., Genaid T.M., Shalaby M.E., Durability Of Bond Strength Of Glass Ionomer To Enamel, Tanta Dental Journal, 12(1), 16-27 (2015).
[17] Somani R., Jaidka S., Singh D.J., Sibal G.K., Comparative Evaluation Of Shear Bond Strength Of Various Glass Ionomer Cements To Dentin Of Primary Teeth: An In Vitro Study, International Journal Of Clinical Pediatric Dentistry, 9(3), 192-196 (2016).
[18] Sari E.A., Nahzi M.Y.I., Maglenda B., Pengaruh Lama Pengeringan Bonding Dengan Bahan Pelarut Aseton Terhadap Kekuatan Ikat Geser Resin Komposit Bioaktif, Dentin-Jurnal Kedokteran Gigi, 4(3), 75-80 (2020).
[19] Alifuddin N.A., Diana S., Maglenda B., Pengaruh Perendaman Water Settable Gic Dalam Air Sungai Dan Air Pdam Terhadap Kekuatan Ikat Geser, Jurnal Kedokteran Gigi, 5(2), 76-80 (2021).
[20] Gc Corporation Catalog, Available At: Https://Www.Gcindiadental.Com/Products/Glass-Ionomers-Restoratives/Gc-Gold-Label-9-Extra-Fuji-9-Extra/, Accessed On 2 May 2021.
[21] Handoko M.W., Tjandrawinata R., Pengaruh Nanofilled Resin Coating Terhadap Kekasaran Permukaan Semen Ionomer Kaca, Jurnal Material Kedokteran Gigi, 8(1), 7-11 (2019).
[22] Meharry M.R., Moazzami S.M., Li Y., Comparison Of Enamel And Dentin Shear Bond Strengths Of Current Dental Bonding Adhesives From Three Bond Generations, Journal Of Operative Dentistry, 38(6), 237-245 (2013).
[23] Sundari I., Perbedaan Kekasaran Permukaan Gic Tanpa Dan Dengan Penambahan Kitosan Setelah Perendaman Minuman Isotonik, Jurnal Material Kedokteran Gigi, 2016, 1(5), 49-55 (2016).
[24] Juliatri, Pangemanan, Fitriyana D.C., Saliva Buatan Meningkatkan Kekuatan Tekan Semen Ionomer Kaca Tipe 2 Yang Direndam Dalam Minuman Isotonic, Dentofasial, 13(2), 101-105 (2014).
[25] Bortoletto C.C., Junior W.G.M., Motta L.J., Bussadori S.K., Influence Of Acid Etching On Shear Strength Of Different Glass Ionomer Cements, Brazilian Journal Of Oral Science, 12(1), 11-15 (2013).
[26] Choudhary K., Nandlal B., Comparative Evaluation Of Shear Bond Strength Of Nano-Hydroxyapatite Incorporated Glass Ionomer Cement And Conventional Glass Ionomer Cement On Dense Synthetic Hydroxyapatite Disk: An In Vitro Study, Indian J Dent Res, 26(2), 170–175 (2015).
[27] Mozartha M., Hidroksiapatit Dan Aplikasinya Di Bidang Kedokteraan Gigi. Cakradonya Dental Journal, 7(2), 807-868 (2015).
[28] Lestari S., Kekuatan Tekan Restorasi Sandwich Berbasis Semen Ionomer Kaca (Sik) Fuji® 2 Dan Fuji® 9, Jurnal Material Kedokteran Gigi, 1(2), 139-144 (2012).
[29] Sungkar S., Peran Kondisioner Pada Adhesi Bahan Restorasi Semen Ionomer Kaca Dengan Struktur Dentin, Cakradonya Dental Journal, 6(2), 678-744 (2014).
[30] Maria R., Dutta S., The Effects Of Various Polishing System On Surface Roughness Of Nano And Microhybrid Composite Restrorative : An Invitro Surface Profilometric Study, Indian Journal Of Basic & Applied Medical Research, 2(1), 214-220 (2012).