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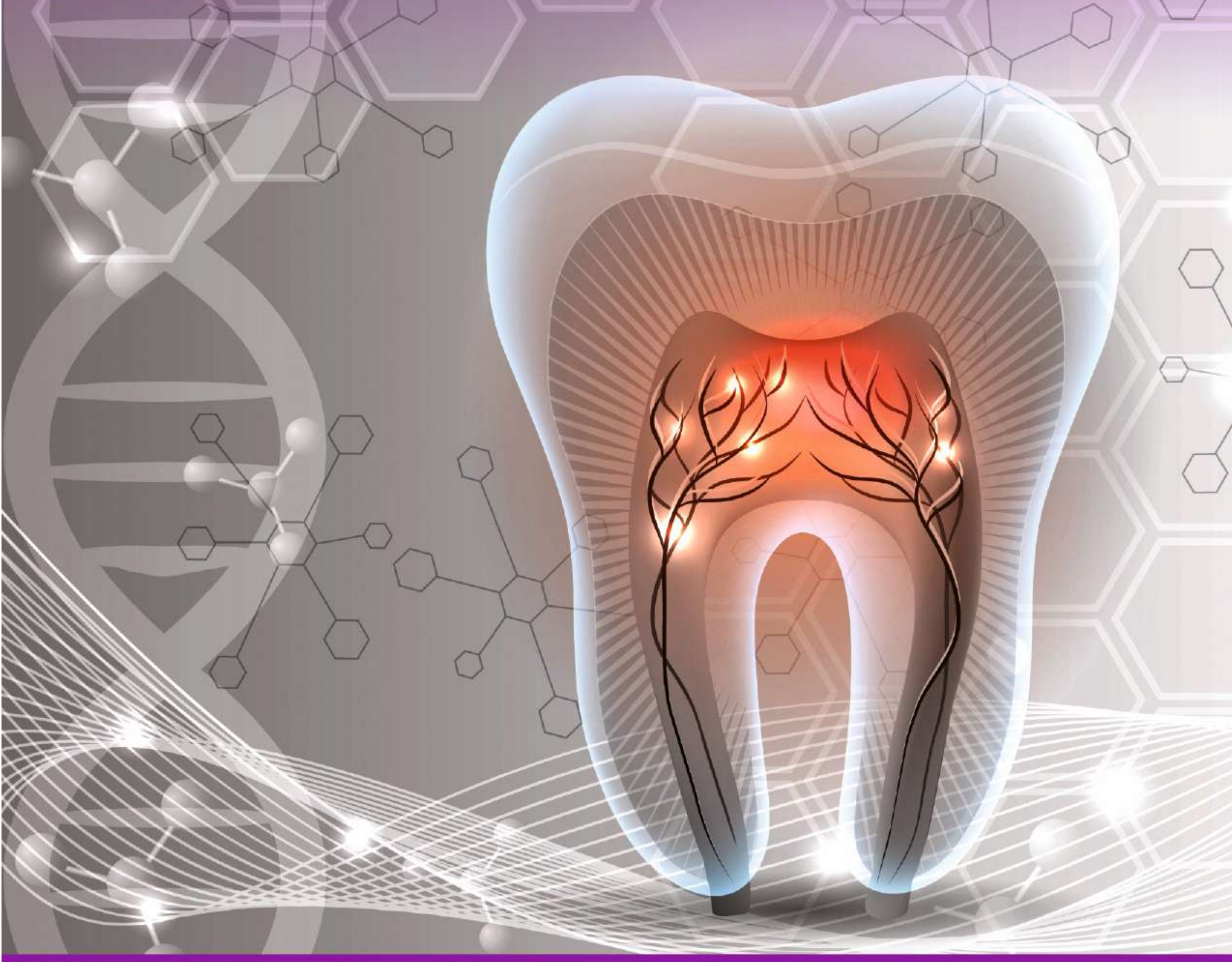

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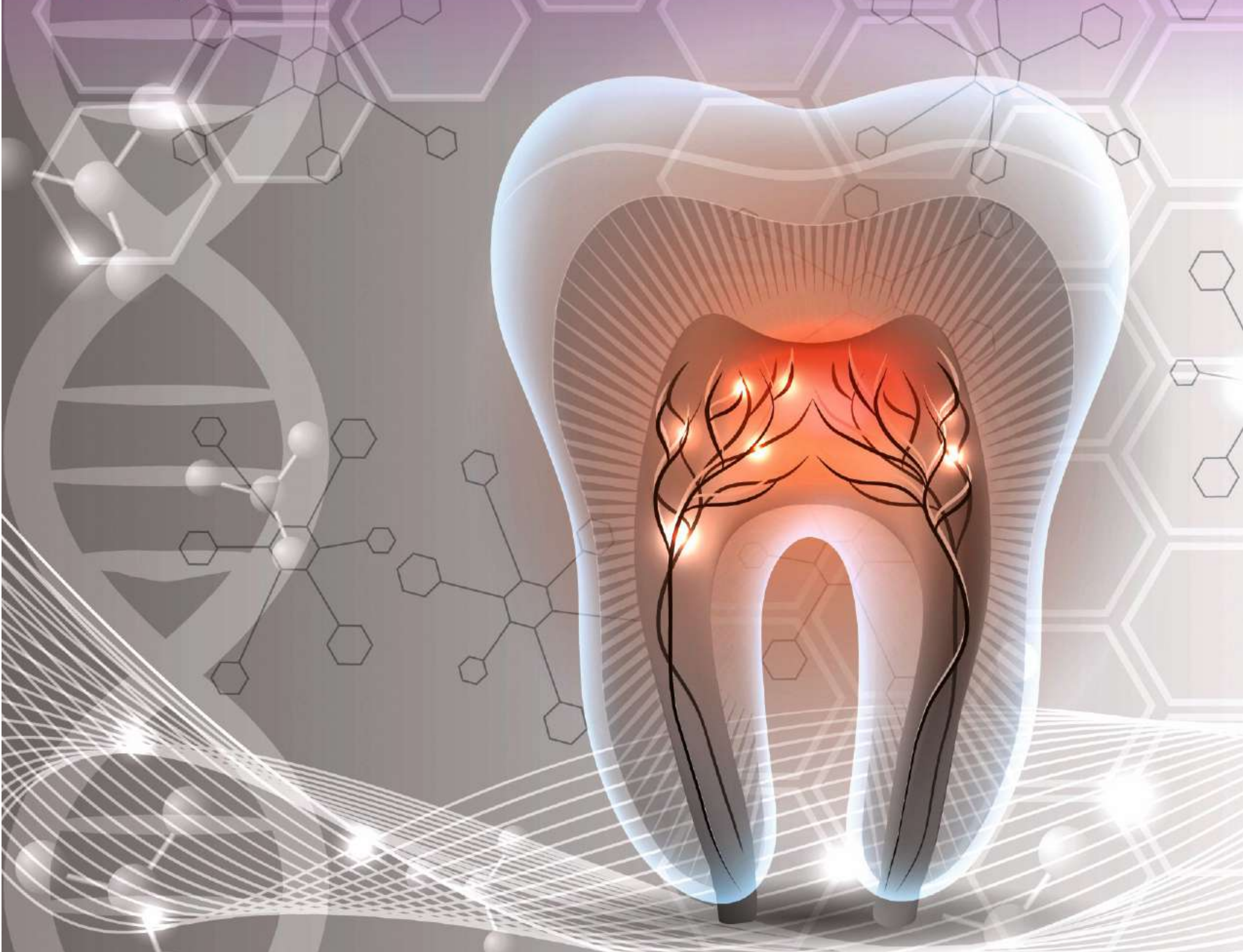

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Original Article

The Effect of Nanofilled Resin Coating on the Hardness of Glass Ionomer Cement

Michael William Handoko, Rosalina Tjandrawinata[1], Octarina[1]

Undergraduate Student, [1]Department of Dental Materials, Faculty of Dentistry, Trisakti University, Jakarta, Indonesia

ABSTRACT

Background: Glass ionomer cement (GIC), a dental material that is constantly being developed and improved, is a biocompatible restorative material with physical, mechanical, and chemical properties that resemble teeth. This material is often used in dentistry because it can release fluoride. However, it has low wear resistance and is very sensitive to moisture, which can reduce the hardness. **Objectives:** The aim of this research is to evaluate the influence of applying nano-filled resin coatings on GIC to increase the hardness, especially after 24 h. **Methods:** This research is a pre-posttest laboratory experiment with a control group design. In this study, GIC Type II (EQUIA Forte® Fil, GC, Japan) was mechanically manipulated and inserted into molds to produce twenty samples of 6.0 ± 0.3 mm in diameter and 3.0 ± 0.2 mm in height. The GIC samples were divided into two groups: ten samples that were not coated with nano-filled resin formed the control group, while the other ten samples that were coated with nano-filled resin (EQUIA Forte Coat, GC, Japan) were the treatment group. The GIC samples were tested immediately using the Vickers hardness (VHN) test and then immersed in sterile distilled water in a 37°C incubator. After 24 h, the GIC samples were tested for their final hardness value. **Results:** The group that received the coating had a greater hardness value (131.14 ± 36.15 VHN) that was statistically significantly higher (*t*-test, $P < 0.05$) than that of the group with no coating (13.56 ± 4.28 VHN). **Conclusion:** Nano-filled resin coating applications on GIC significantly increase the hardness after 24 h.

Keywords: *Glass ionomer cement, hardness, nano-filled resin coating*

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Background

Glass ionomer cement (GIC) is a restorative material that is constantly being developed and improved in both composition and technology.[1,2] GIC restorative material has some advantages, such as minimal preparation, the release of fluoride over a long period of time, good flexural strength, and biocompatibility.[3] This material has undergone many improvements since its introduction by Wilson and Kent in the dentistry field in 1972. GIC is a generic name for a group of materials that use a fluor aluminosilicate glass silicate powder and a polyacrylic acid solution. The hardening reaction occurs when the glass powder and polyacrylic acid solution are mixed. This causes an acid–base reaction where the glass powder serves as the base.

Conventional GIC is usually used for restoration in areas such as the anterior teeth, where high chewing force is not required.[4] This type of GIC is also recommended for filling teeth with Class III and V preparations.[2] The GIC can produce very strong adhesion bonds to tooth structures, so it is useful for conservative restoration in areas where erosion occurs frequently.

Many dentists currently use a composite restoration material rather than GIC restorative material. There are many reasons why composite resin is better than GIC.

Address for correspondence: Dr. Rosalina Tjandrawinata, Department of Dental Materials, Faculty of Dentistry, Trisakti University, West Jakarta, Indonesia.
E-mail: rosalina@trisakti.ac.id

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One reason is that composite resin has improved esthetic properties. In addition, composite restoration material has better adhesive capacity as a result of modern dentin adhesives and increased mechanical properties.[5] However, composite resin restoration can cause pulp irritation, polymerization shrinkage, and microleakage.[6] Microleakage can result in inflammatory changes, secondary caries, and discoloration of the restoration, which in the long term leads to the restoration being a failure.[7,8]

Therefore, the development of GIC restorative material is accomplished because this material can release fluoride, is biocompatible, and does not shrink. Development of this material, which is presented in the capsule system, makes GIC easier to apply, gives it better consistency, and can be refined afterward through application of a nano-filled resin coating.[9] The application of nano-filled resin coatings is expected to increase the hardness of the GIC. Therefore, the purpose of this research is to evaluate the effect of nano-filled resin coating application on the GIC hardness.

Materials and Methods

This research is a pre-posttest laboratory experiment with a control group design. GIC (EQUIA Forte® Fil, LOT 1701251, GC, Tokyo, Japan) samples were made from twenty molds of 6.0 ± 0.3 mm in diameter and 3.0 ± 0.2 mm in height.

The GIC mixing was done mechanically using the HSM 3 High-Speed Mixer (GC Asia Pte Ltd, Singapore) for 10 s.[10] After completing the mixing, the GIC capsule was taken from the HSM 3 High-Speed Mixer and inserted into a capsule applier, with the tip of a syringe facing toward the mold. Then, the sample mold was filled to the brim by pressing the capsule tube using the capsule applier. After the mold was completely filled, it was pressed for 60 s using a Mylar strip and glass plate, resulting in a solid and flat surface. After hardening, the GIC sample was removed using a cement stopper.

The twenty samples were divided into two groups: ten samples as the control group (not coated) and ten samples as the treatment group (coated). The samples in the treatment group were smeared with thin layers of nano-filled resin coating (EQUIA Forte Coat, LOT 1612061, GC, Japan) using micro brushes. The samples in the treatment group were then cured for 20 s with cordless light-emitting diode-curing light (BlueLex LD-M4, Monitex Industrial Co., New Taipei City, Taiwan). After this, the samples in both the control group and the treatment group were mounted in pipes using self-curing acrylic resin and hardness tested.[11]

All samples were tested using the Vickers hardness (VHN) tester, with indentation times of 15 s and loads of 300 g. The indentation was done three times in each of the GIC samples. After tested for initial hardness, the GIC samples from both groups were placed in 250-mL beaker glasses filled with sterile distilled water until the surfaces of the GIC samples were completely submerged. The beaker glasses were then placed into a 37°C incubator. After 24 h, the GIC samples from both groups were once again tested for hardness.

Data analysis was carried out for both the control group and the treatment group. Before analysis, the data were tested for normality using the Shapiro–Wilk test. Because the data from both groups were normally distributed, they were analyzed using an unpaired *t*-test.

Results

Table 1 shows the mean increases in the values of the hardness from both the control group and the treatment group. It can be seen that the mean increase of the hardness in the treatment group is higher than that of the control group.

Figure 1 shows that after 24 h, the hardness in the control group samples, which were not coated with nano-filled resin, increased by 18.1%, whereas the samples of the treatment group [Figure 2], which had the nano-filled resin coatings, increased by 163.5%.

Normality test using the Shapiro–Wilk test showed that the data in the control group were 0.18 ($P > 0.05$) and the result in the treatment group were 0.22 ($P > 0.05$).

Table 1: Mean increase in hardness (Vickers hardness)

Variable	Mean±SD
Control (not coated)	13.56±4.28
Treatment (coated)	131.14±36.15

SD: Standard deviation

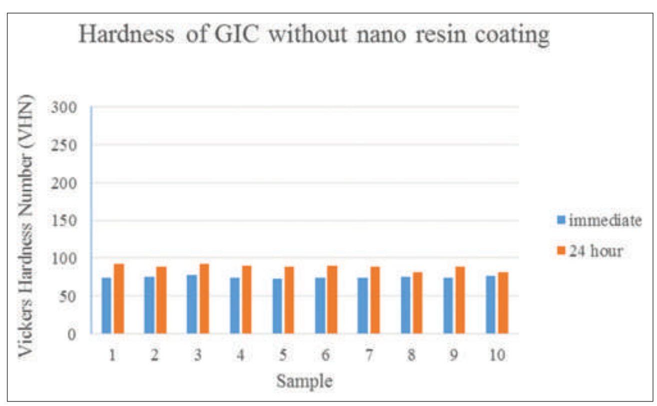

Figure 1: Hardness of the control group samples without nano-filled resin coating, both immediately and after 24 h

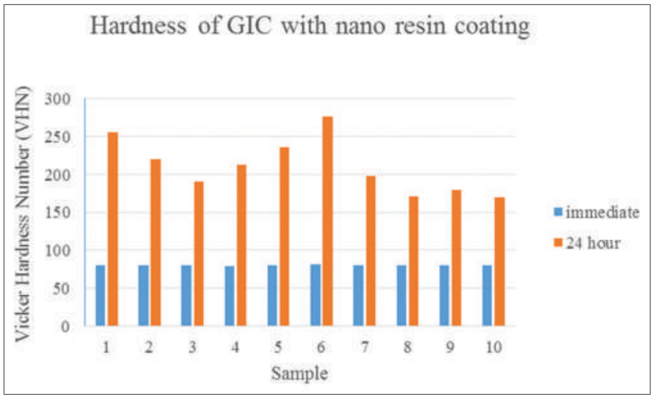

Figure 2: Hardness of the treatment group samples with applied nano-filled resin coating, both immediately and after 24 h

This result showed that the data from both groups were normally distributed. The data were then analyzed using an unpaired *t*-test, which obtained values of $P < 0.05$, which indicates that there was a significant difference in the increases of the hardness between the control and treatment groups.

Discussion

This research was conducted to evaluate the latest generation of GIC that is developed to provide higher physical properties than conventional GIC. A new material, which is based on glass hybrid technology called EQUIA Forte (GC, Japan), was launched in 2015. It consists of a highly viscous conventional GIC (EQUIA Forte Fil, GC, Japan) combined with a nano-filled coating material (EQUIA Forte Coat, GC, Japan).[12] The powder consists of 95% strontium fluor aluminosilicate glass and 5% polyacrylic acid, including newly added highly reactive small particles and a liquid component consisting of 40% aqueous polyacrylic acid.[13] The innovation of the EQUIA Forte Fil glass hybrid is achieved through the introduction of ultrafine glass particles that are highly reactive and dispersed in conventional GIC structures. The addition of high-molecular-weight polyacrylate acids can form a GIC restoration with higher strength and hardness.[14]

There are 50% methyl methacrylate and 0.09% camphorquinone in the EQUIA Forte Coat. The GIC surface is sealed by the hydrophilic low-viscosity nano-filled resin coating so that the abrasive wear and the possibility of fracture of the restoration are reduced for the 1st months until complete maturation is achieved.[13] The former type of GIC used varnish, which was reported to have a strong smell and taste, due to solvents and to its acrylic nature.[15] However, this new type of coating material has less smell in comparison with varnish. The esthetics are also improved through a glazed effect.[9,16] In addition, the clinical performance of the newly developed restorative system has been shown to be satisfying.[17,18] One of the most important properties of GIC-based materials can be found in their anticariogenic character. Delayed demineralization of adjacent sound teeth and remineralization of demineralized underlying dentin are caused by the restorative material that releases fluoride.[19,20]

Generally, the hardening process that occurs in GIC is characterized by an interaction between a solution of polyacrylate acid and aluminosilicate glass powder in the form of an acid–base reaction.[21] This reaction is characterized by gradual and long-lasting hardening phases. In these phases, changes in physical and mechanical properties occur, particularly those that increase the hardness and strength during the first 24 h. Increased hardness and strength can also be observed for the next few weeks and months.[14]

In this study, it was shown that the hardness of GIC surface increases nine times higher after the application of resin coating. The initial hardening phase of GIC can be observed within 3–6 min after the mixing process.[14] In this phase, the GIC mixture must be protected from water contamination and dehydration to prevent a decrease in physical and mechanical properties.[14] Previous research has observed that because of the initial moisture contamination, the mechanical properties of the GIC decrease, and the surfaces become more susceptible to erosion and abrasion.[16] Other research also emphasizes that water contamination must be prevented during the initial phase of the GIC hardening, in the first 24 h; although over time the surface coatings will be reduced because of the mastication process.[14] However, with this process, the resistance of GIC against water contamination is increased because it has passed the initial hardening phase.[14,22]

Among the coating strategies, light polymerized resin coatings have been considered to be the optimal surface-protecting agent because it can limit water movement across the settings of the GIC surfaces.[22] In addition, in 1990, the American Dental Association declared the importance of varnishes or light polymerized bonding agents for conventional GIC restorations.[22] The manufacturers of Equia Forte Coat report that the product contains nanofillers. Increasing the filler content enhances the mechanical properties of the restorative material,[23] and restoration that contains small-sized fillers such as nanofillers exhibits better wear resistance than restorative material containing large fillers.[24] This final lamination enables a smooth and glossy surface to form, which strengthens, protects, and enhances the hardness of all the GIC restorations and protects the restoration

surface against excessive water contamination during the initial hardening phase.[24] Moreover, the coating provides a dispersion hardened surface. It bonds well to the tooth, the restoration surface, and fills the voids, therefore the mechanical stress gets dispersed by the toughened laminated layer.[24] Further research is suggested to analyze the hardness after 7 days, considering the hardening phase of GIC.

Conclusion

Based on the results of this research, it can be concluded that applying nano-filled resin coating has a significant effect with regard to increasing the hardness of GIC. This effect can be caused by inhibiting contact with water in the initial hardening phase. The GIC then becomes harder, especially during the initial 24 h.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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The Effect of Nanofilled Resin Coating on the Hardness of Glass Ionomer Cement

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Original Article

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Michael William Handoko, Rosalina Tjandrawinata[1], Octarina[1]

Undergraduate Student, [1]Department of Dental Materials, Faculty of Dentistry, Trisakti University, Jakarta, Indonesia

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BACKGROUND

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Many dentists currently use a composite restoration material rather than GIC restorative material. There are many reasons why composite resin is better than GIC.

Address for correspondence: Dr. Rosalina Tjandrawinata, Department of Dental Materials, Faculty of Dentistry, Trisakti University, West Jakarta, Indonesia.
E-mail: rosalina@trisakti.ac.id

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One reason is that composite resin has improved esthetic properties. In addition, composite restoration material has better adhesive capacity as a result of modern dentin adhesives and increased mechanical properties.[5] However, composite resin restoration can cause pulp irritation, polymerization shrinkage, and microleakage.[6] Microleakage can result in inflammatory changes, secondary caries, and discoloration of the restoration, which in the long term leads to the restoration being a failure.[7,8]

Therefore, the development of GIC restorative material is accomplished because this material can release fluoride, is biocompatible, and does not shrink. Development of this material, which is presented in the capsule system, makes GIC easier to apply, gives it better consistency, and can be refined afterward through application of a nano-filled resin coating.[9] The application of nano-filled resin coatings is expected to increase the hardness of the GIC. Therefore, the purpose of this research is to evaluate the effect of nano-filled resin coating application on the GIC hardness.

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Data analysis was carried out for both the control group and the treatment group. Before analysis, the data were tested for normality using the Shapiro–Wilk test. Because the data from both groups were normally distributed, they were analyzed using an unpaired *t*-test.

Results

Table 1 shows the mean increases in the values of the hardness from both the control group and the treatment group. It can be seen that the mean increase of the hardness in the treatment group is higher than that of the control group.

Figure 1 shows that after 24 h, the hardness in the control group samples, which were not coated with nano-filled resin, increased by 18.1%, whereas the samples of the treatment group [Figure 2], which had the nano-filled resin coatings, increased by 163.5%.

Normality test using the Shapiro–Wilk test showed that the data in the control group were 0.18 ($P > 0.05$) and the result in the treatment group were 0.22 ($P > 0.05$).

Table 1: Mean increase in hardness (Vickers hardness)

Variable	Mean±SD
Control (not coated)	13.56±4.28
Treatment (coated)	131.14±36.15

SD: Standard deviation

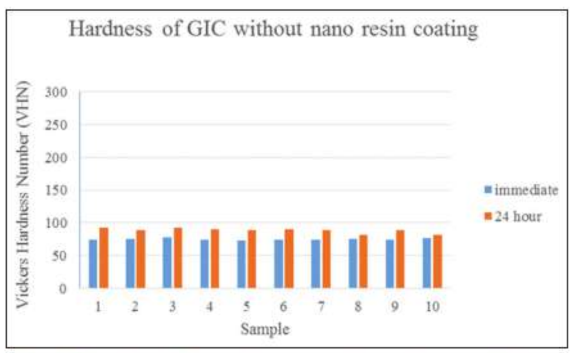

Figure 1: Hardness of the control group samples without nano-filled resin coating, both immediately and after 24 h

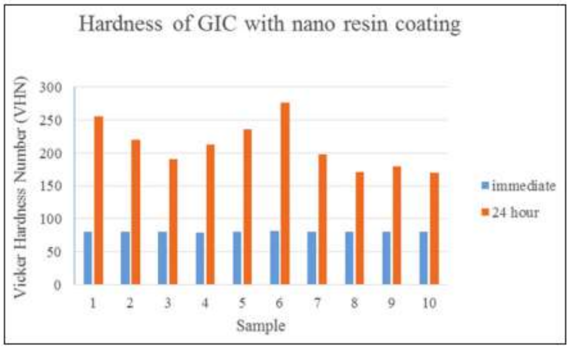

Figure 2: Hardness of the treatment group samples with applied nano-filled resin coating, both immediately and after 24 h

This result showed that the data from both groups were normally distributed. The data were then analyzed using an unpaired t-test, which obtained values of $P < 0.05$, which indicates that there was a significant difference in the increases of the hardness between the control and treatment groups.

Discussion

This research was conducted to evaluate the latest generation of GIC that is developed to provide higher physical properties than conventional GIC. A new material, which is based on glass hybrid technology called EQUIA Forte (GC, Japan), was launched in 2015. It consists of a highly viscous conventional GIC (EQUIA Forte Fil, GC, Japan) combined with a nano-filled coating material (EQUIA Forte Coat, GC, Japan).[12] The powder consists of 95% strontium fluor aluminosilicate glass and 5% polyacrylic acid, including newly added highly reactive small particles and a liquid component consisting of 40% aqueous polyacrylic acid.[13] The innovation of the EQUIA Forte Fil glass hybrid is achieved through the introduction of ultrafine glass particles that are highly reactive and dispersed in conventional GIC structures. The addition of high-molecular-weight polyacrylate acids can form a GIC restoration with higher strength and hardness.[14]

There are 50% methyl methacrylate and 0.09% camphorquinone in the EQUIA Forte Coat. The GIC surface is sealed by the hydrophilic low-viscosity nano-filled resin coating so that the abrasive wear and the possibility of fracture of the restoration are reduced for the 1st months until complete maturation is achieved.[13] The former type of GIC used varnish, which was reported to have a strong smell and taste, due to solvents and to its acrylic nature.[15] However, this new type of coating material has less smell in comparison with varnish. The esthetics are also improved through a glazed effect.[9,16] In addition, the clinical performance of the newly developed restorative system has been shown to be satisfying.[17,18] One of the most important properties of GIC-based materials can be found in their anticariogenic character. Delayed demineralization of adjacent sound teeth and remineralization of demineralized underlying dentin are caused by the restorative material that releases fluoride.[19,20]

Generally, the hardening process that occurs in GIC is characterized by an interaction between a solution of polyacrylate acid and aluminosilicate glass powder in the form of an acid–base reaction.[21] This reaction is characterized by gradual and long-lasting hardening phases. In these phases, changes in physical and mechanical properties occur, particularly those that increase the hardness and strength during the first 24 h. Increased hardness and strength can also be observed for the next few weeks and months.[14]

In this study, it was shown that the hardness of GIC surface increases nine times higher after the application of resin coating. The initial hardening phase of GIC can be observed within 3–6 min after the mixing process.[14] In this phase, the GIC mixture must be protected from water contamination and dehydration to prevent a decrease in physical and mechanical properties.[14] Previous research has observed that because of the initial moisture contamination, the mechanical properties of the GIC decrease, and the surfaces become more susceptible to erosion and abrasion.[16] Other research also emphasizes that water contamination must be prevented during the initial phase of the GIC hardening, in the first 24 h; although over time the surface coatings will be reduced because of the mastication process.[14] However, with this process, the resistance of GIC against water contamination is increased because it has passed the initial hardening phase.[14,22]

Among the coating strategies, light polymerized resin coatings have been considered to be the optimal surface-protecting agent because it can limit water movement across the settings of the GIC surfaces.[22] In addition, in 1990, the American Dental Association declared the importance of varnishes or light polymerized bonding agents for conventional GIC restorations.[22] The manufacturers of Equia Forte Coat report that the product contains nanofillers. Increasing the filler content enhances the mechanical properties of the restorative material,[23] and restoration that contains small-sized fillers such as nanofillers exhibits better wear resistance than restorative material containing large fillers.[24] This final lamination enables a smooth and glossy surface to form, which strengthens, protects, and enhances the hardness of all the GIC restorations and protects the restoration

surface against excessive water contamination during the initial hardening phase.[24] Moreover, the coating provides a dispersion hardened surface. It bonds well to the tooth, the restoration surface, and fills the voids, therefore the mechanical stress gets dispersed by the toughened laminated layer.[24] Further research is suggested to analyze the hardness after 7 days, considering the hardening phase of GIC.

Conclusion

Based on the results of this research, it can be concluded that applying nano-filled resin coating has a significant effect with regard to increasing the hardness of GIC. This effect can be caused by inhibiting contact with water in the initial hardening phase. The GIC then becomes harder, especially during the initial 24 h.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Original Article

The Effect of Nanofilled Resin Coating on the Hardness of Glass Ionomer Cement

Michael William Handoko, Rosalina Tjandrawinata[1], Octarina[1]

Undergraduate Student,
[1]Department of Dental Materials, Faculty of Dentistry, Trisakti University, Jakarta, Indonesia

ABSTRACT

Background: Glass ionomer cement (GIC), a dental material that is constantly being developed and improved, is a biocompatible restorative material with physical, mechanical, and chemical properties that resemble teeth. This material is often used in dentistry because it can release fluoride. However, it has low wear resistance and is very sensitive to moisture, which can reduce the hardness. **Objectives:** The aim of this research is to evaluate the influence of applying nano-filled resin coatings on GIC to increase the hardness, especially after 24 h. **Methods:** This research is a pre-posttest laboratory experiment with a control group design. In this study, GIC Type II (EQUIA Forte® Fil, GC, Japan) was mechanically manipulated and inserted into molds to produce twenty samples of 6.0 ± 0.3 mm in diameter and 3.0 ± 0.2 mm in height. The GIC samples were divided into two groups: ten samples that were not coated with nano-filled resin formed the control group, while the other ten samples that were coated with nano-filled resin (EQUIA Forte Coat, GC, Japan) were the treatment group. The GIC samples were tested immediately using the Vickers hardness (VHN) test and then immersed in sterile distilled water in a 37°C incubator. After 24 h, the GIC samples were tested for their final hardness value. **Results:** The group that received the coating had a greater hardness value (131.14 ± 36.15 VHN) that was statistically significantly higher (*t*-test, $P < 0.05$) than that of the group with no coating (13.56 ± 4.28 VHN). **Conclusion:** Nano-filled resin coating applications on GIC significantly increase the hardness after 24 h.

Keywords: *Glass ionomer cement, hardness, nano-filled resin coating*

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Background

Glass ionomer cement (GIC) is a restorative material that is constantly being developed and improved in both composition and technology.[1,2] GIC restorative material has some advantages, such as minimal preparation, the release of fluoride over a long period of time, good flexural strength, and biocompatibility.[3] This material has undergone many improvements since its introduction by Wilson and Kent in the dentistry field in 1972. GIC is a generic name for a group of materials that use a fluor aluminosilicate glass silicate powder and a polyacrylic acid solution. The hardening reaction occurs when the glass powder and polyacrylic acid solution are mixed. This causes an acid–base reaction where the glass powder serves as the base.

Conventional GIC is usually used for restoration in areas such as the anterior teeth, where high chewing force is not required.[4] This type of GIC is also recommended for filling teeth with Class III and V preparations.[2] The GIC can produce very strong adhesion bonds to tooth structures, so it is useful for conservative restoration in areas where erosion occurs frequently.

Many dentists currently use a composite restoration material rather than GIC restorative material. There are many reasons why composite resin is better than GIC.

Address for correspondence: Dr. Rosalina Tjandrawinata, Department of Dental Materials, Faculty of Dentistry, Trisakti University, West Jakarta, Indonesia.
E-mail: rosalina@trisakti.ac.id

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One reason is that composite resin has improved esthetic properties. In addition, composite restoration material has better adhesive capacity as a result of modern dentin adhesives and increased mechanical properties.[5] However, composite resin restoration can cause pulp irritation, polymerization shrinkage, and microleakage.[6] Microleakage can result in inflammatory changes, secondary caries, and discoloration of the restoration, which in the long term leads to the restoration being a failure.[7,8]

Therefore, the development of GIC restorative material is accomplished because this material can release fluoride, is biocompatible, and does not shrink. Development of this material, which is presented in the capsule system, makes GIC easier to apply, gives it better consistency, and can be refined afterward through application of a nano-filled resin coating.[9] The application of nano-filled resin coatings is expected to increase the hardness of the GIC. Therefore, the purpose of this research is to evaluate the effect of nano-filled resin coating application on the GIC hardness.

Materials and Methods

This research is a pre-posttest laboratory experiment with a control group design. GIC (EQUIA Forte® Fil, LOT 1701251, GC, Tokyo, Japan) samples were made from twenty molds of 6.0 ± 0.3 mm in diameter and 3.0 ± 0.2 mm in height.

The GIC mixing was done mechanically using the HSM 3 High-Speed Mixer (GC Asia Pte Ltd, Singapore) for 10 s.[10] After completing the mixing, the GIC capsule was taken from the HSM 3 High-Speed Mixer and inserted into a capsule applier, with the tip of a syringe facing toward the mold. Then, the sample mold was filled to the brim by pressing the capsule tube using the capsule applier. After the mold was completely filled, it was pressed for 60 s using a Mylar strip and glass plate, resulting in a solid and flat surface. After hardening, the GIC sample was removed using a cement stopper.

The twenty samples were divided into two groups: ten samples as the control group (not coated) and ten samples as the treatment group (coated). The samples in the treatment group were smeared with thin layers of nano-filled resin coating (EQUIA Forte Coat, LOT 1612061, GC, Japan) using micro brushes. The samples in the treatment group were then cured for 20 s with cordless light-emitting diode-curing light (BlueLex LD-M4, Monitex Industrial Co., New Taipei City, Taiwan). After this, the samples in both the control group and the treatment group were mounted in pipes using self-curing acrylic resin and hardness tested.[11]

All samples were tested using the Vickers hardness (VHN) tester, with indentation times of 15 s and loads of 300 g. The indentation was done three times in each of the GIC samples. After tested for initial hardness, the GIC samples from both groups were placed in 250-mL beaker glasses filled with sterile distilled water until the surfaces of the GIC samples were completely submerged. The beaker glasses were then placed into a 37°C incubator. After 24 h, the GIC samples from both groups were once again tested for hardness.

Data analysis was carried out for both the control group and the treatment group. Before analysis, the data were tested for normality using the Shapiro–Wilk test. Because the data from both groups were normally distributed, they were analyzed using an unpaired *t*-test.

Results

Table 1 shows the mean increases in the values of the hardness from both the control group and the treatment group. It can be seen that the mean increase of the hardness in the treatment group is higher than that of the control group.

Figure 1 shows that after 24 h, the hardness in the control group samples, which were not coated with nano-filled resin, increased by 18.1%, whereas the samples of the treatment group [Figure 2], which had the nano-filled resin coatings, increased by 163.5%.

Normality test using the Shapiro–Wilk test showed that the data in the control group were 0.18 ($P > 0.05$) and the result in the treatment group were 0.22 ($P > 0.05$).

Table 1: Mean increase in hardness (Vickers hardness)

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Treatment (coated)	131.14±36.15

SD: Standard deviation

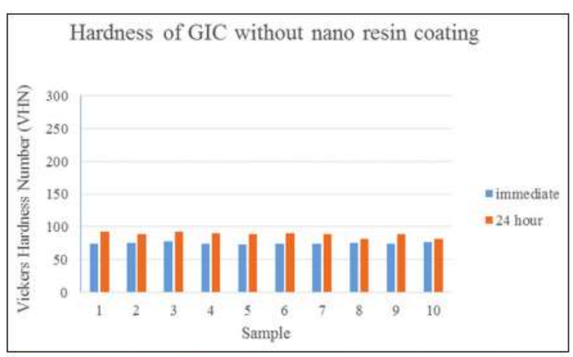

Figure 1: Hardness of the control group samples without nano-filled resin coating, both immediately and after 24 h

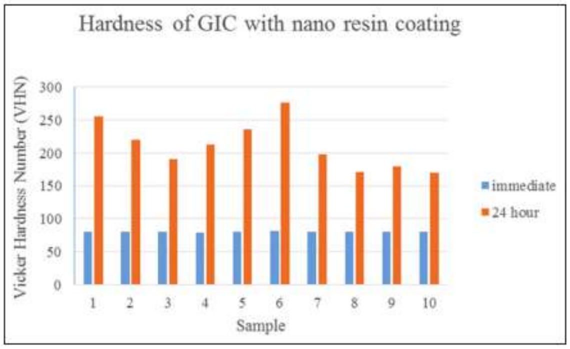

Figure 2: Hardness of the treatment group samples with applied nano-filled resin coating, both immediately and after 24 h

This result showed that the data from both groups were normally distributed. The data were then analyzed using an unpaired *t*-test, which obtained values of $P < 0.05$, which indicates that there was a significant difference in the increases of the hardness between the control and treatment groups.

Discussion

This research was conducted to evaluate the latest generation of GIC that is developed to provide higher physical properties than conventional GIC. A new material, which is based on glass hybrid technology called EQUIA Forte (GC, Japan), was launched in 2015. It consists of a highly viscous conventional GIC (EQUIA Forte Fil, GC, Japan) combined with a nano-filled coating material (EQUIA Forte Coat, GC, Japan).[12] The powder consists of 95% strontium fluor aluminosilicate glass and 5% polyacrylic acid, including newly added highly reactive small particles and a liquid component consisting of 40% aqueous polyacrylic acid.[13] The innovation of the EQUIA Forte Fil glass hybrid is achieved through the introduction of ultrafine glass particles that are highly reactive and dispersed in conventional GIC structures. The addition of high-molecular-weight polyacrylate acids can form a GIC restoration with higher strength and hardness.[14]

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