



UNIVERSIDADE FEDERAL DE UBERLÂNDIA
FACULDADE DE ODONTOLOGIA



ANA CECÍLIA TEODORO SCHETTINI

**EFFECT OF METHOD USED FOR SAMPLE
PREPARATION AND LIGHT CURING DESIGN ON
KNOOP HARDNESS AND DEGREE OF CONVERSION ON
BULK FILL COMPOSITE RESIN IN MOLAR TEETH**

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KNOOP HARDNESS AND DEGREE OF
CONVERSION ON BULK FILL COMPOSITE RESIN
IN MOLAR TEETH**

Trabalho de conclusão de curso apresentado a Faculdade de Odontologia da UFU, como requisito parcial para obtenção do título de Graduado em Odontologia.

Orientador: Prof. Dr. Carlos José Soares

Co-orientadora: Me. Stella Sueli Lourenço Braga

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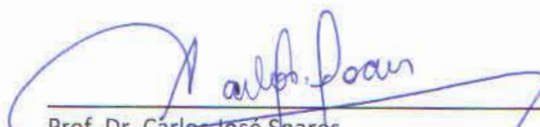


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TRABALHO DE CONCLUSÃO DE CURSO

ATA DA COMISSÃO JULGADORA DA DEFESA DE TRABALHO DE CONCLUSÃO DE CURSO DO (A) DISCENTE **Ana Cecília Teodoro Schettini** DA FACULDADE DE ODONTOLOGIA DA UNIVERSIDADE FEDERAL DE UBERLÂNDIA.

No dia **26 de junho de 2019**, reuniu-se a Comissão Julgadora aprovada pelo Colegiado de Graduação da Faculdade de Odontologia da Universidade Federal de Uberlândia, para o julgamento do Trabalho de Conclusão de Curso apresentado pelo(a) aluno(a) **Ana Cecília Teodoro Schettini**, COM O TÍTULO: **"EFFECT OF METHOD USED FOR SAMPLE PREPARATION AND LIGHT CURING DESIGN ON KNOOP HARDNESS AND DEGREE OF CONVERSION ON BULK FILL COMPOSITE RESIN IN MOLAR TEETH"**. O julgamento do trabalho foi realizado em sessão pública compreendendo a exposição, seguida de arguição pelos examinadores. Encerrada a arguição, cada examinador, em sessão secreta, exarou o seu parecer. A Comissão Julgadora, após análise do Trabalho, verificou que o mesmo se encontra em condições de ser incorporado ao banco de Trabalhos de Conclusão de Curso desta Faculdade. O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas da Graduação, legislação e regulamentação da UFU. Nada mais havendo a tratar foram encerrados os trabalhos e lavrada a presente ata, que após lida e achada conforme, foi assinada pela Banca Examinadora.

Uberlândia, 26 de junho de 2019.

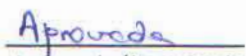

Prof. Dr. Carlos José Soares
Universidade Federal de Uberlândia – UFU

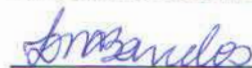

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*À Deus, que tanto me abençoou
durante todo o tempo. Aos meus
pais Eli e Fabyana, ao meu
padrasto Almir, aos meus irmãos
Ana Laura, João Vítor e Beatriz,
aos meus avós Wagner e Cristina,
ao meu noivo Leonardo e à toda
minha família, pelo apoio, carinho
e amparo que nunca me faltaram.*

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EPÍGRAFE

*“Conheça todas as teorias,
domine todas as técnicas, mas
ao tocar uma alma humana, seja
apenas outra alma humana.”*

Carl G. Jung

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Effect of method used for sample preparation and light curing design on Knoop hardness and degree of conversion on bulk fill composite resin in molar teeth

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Effect of method used for sample preparation and light curing design on Knoop hardness and degree of conversion on bulk fill composite resin in molar teeth

RUNNING TITLE: Effect of sample preparation and LCU design on mechanical properties

CLINICAL RELEVANCE: Performing restorations and sample preparation methods under the conventional condition do not represent the clinical circumstance, *in vitro* studies should then simulate restoration under clinical conditions instead of being ideally performed. Mechanical properties such as Degree of Conversion and Knoop Hardness are depended on the sample preparation method. Clinicians should be more attentive to the proximal boxes when performing Class II restorations once the technique developed raises up a concern about the under polymerization in those areas.

ABSTRACT

OBJECTIVES: The aim of this study was to evaluate the effect of the sample preparation of bulk fill resin composites in molar influenced by the light curing units (LCUs) on Knoop hardness (KHN, N/mm²) and degree of conversion (DC, %) in different depths and regions.

METHODS: Two molar teeth were selected. One molar was embedded in polystyrene resin, sectioned in three parts and received a MOD preparation with lateral cavities surfaces pre-polished and the other one was embedded and the MOD cavity was performed. Standardized expulsive cavity with 4 mm depth in the occlusal area and 5 mm at the proximal were made. Patient simulator with 44 mm of mouth opening had the molar teeth positioned as a second mandibular molar. Restorations were performed using a high viscosity bulk fill resin composite (Opus Bulk Fill, FGM) and light cured using two LCUs: VALO Cordless (Ultradent) and Bluephase G2 (Ivoclar-Vivadent). The resin composite was placed in one increment and light-cured for 40 s on distal and mesial occlusal surfaces. Samples were prepared: CEmPol, performed conventionally, embedded in polystyrene resin and polished before testing; CPol; performed conventionally, without embedment in polystyrene resin but polished before testing; PrePol, performed in a pre-polished molar cavity with no embedment or polishing before testing. KHN was calculated in different depths in two regions of mesial, occlusal and distal cavities. The degree of conversion was measured by Raman spectroscopy at the top and bottom of mesial,

distal and at occlusal regions. Data of KHN and DC were analyzed by using 2-way repeated measurement followed by Tukey test ($\alpha = 0.05$).

RESULTS: Sample preparation method ($P < 0.001$), depth of restoration ($P < 0.001$) and the interaction between sample method and depth of restoration ($P = 0.003$) influence the KHN values. Significant influence was detected for sample confection method ($P < 0.001$), tooth region ($P < 0.001$), and for interaction between sample confection method and tooth region ($P = 0.002$) for DC values. In general, KHN reduced significantly from the top to the bottom of the restoration, mainly at proximal boxes. The PrePol method was the more efficient method to detect the significant difference for depth of the restoration and tooth region. Lower DC was found on the gingival region on the proximal box on the restoration, irrespective of the location being mesial, occlusal or distal area.

CONCLUSION: The sample preparation that was embedded and polished had the uncompleted polymerized monomers layer removed due to the polishing process reducing the capacity of detection of KHN and DC values of bulk fill composite restorations influenced by depth or region of the cavities. The use of PrePol method was able to detect difference produced by light activation in deeper areas.

INTRODUCTION

The use of resin-based composite (RBC), with 2 mm increment thickness, for many years has been recognized as the best option to obtain a great hardness, polymerization degree and low shrinkage stress¹. However, the use of the incremental layering technique when restoring deep cavities requires a longer time and it is more likely to incorporate voids or to cause contamination between layers². The necessity for quick strategies to perform the restoration of deep dental cavities led to the development and commercialization of new materials capable of increasing the depth of curing³⁻⁵.

The bulk fill resin composites enable restorations of 4-5 mm depth using one increment only with similar mechanical properties of the material due to the great capacity to transmit the light⁶. The light-curing process is a critical procedure in the resin composite restorations, is largely dependent on the appropriate polymerization of the material⁴, though it is often overlooked⁷⁻¹⁰. The ideal curing of the resin composite, should be involved less exposure time as possible, lower shrinkage stress, uniform conversion of monomers in all the composite extension¹¹. Four aspects are highly important regarding the polymerization of resin-based composites: the light-curing unit used, the restorative protocol, the extension and location of the restoration, and the energy

received by the composite resin¹²⁻¹⁴. The new light-curing units make possible the curing of composites with alternative photoinitiators besides the camphorquinone present in the conventional resins composite, improving properties such as polymerization and superficial properties due to their broad spectrum⁹. When the curing process is performed incorrectly, it may lead to a premature fail of composite resin restorations ¹⁵.

Restorations in posteriors areas are considered to be challenging for clinicians due to the interference of dental structures, misaligned regions, type of the restorative material and the difficulty of placing the light-curing unit in the most adequate position⁹. The buccal opening interferes directly with the tip positioning, where an interincisal opening of 45 mm is easier to place the tip than 25 mm interincisal opening^{15,16}. Another important aspect to be taken under account is children that show an average of 39 mm of mouth opening on the age of 6¹⁷, and patients with reduced mouth opening or trismus that may present buccal opening limited to a maximum of 20mm¹⁸. The design of the LCUs, influenced by shape and the angulation of the tips, can limit the ideal position of the tip¹⁹. This combination of the factors: limited mouth opening and LCU design, increasing the distance between the proximal boxes and the LCU tip may results in lower irradiance⁴ in distal class II restorations, not reaching an adequate polymerization of the material in that area. An inadequate or insufficient polymerization of the resin composites influences on its mechanical properties, solubility, dimensional and color stability, and biocompatibility²⁰. The hardness test and degree conversion measurement using Raman spectroscopy are methods used to quantify different factors on the polymerization process of posterior composite restoration²¹. However, during the sample preparation, the resin composite restorations are usually embedded in polystyrene resin which involves additional heating, which may contribute with additional polymerization of the tested restoration. Additionally, the surface should be flat and polished for adequate measurement of KHN and DC, then the polishing of the restoration is frequently performed. During this procedure, part of the resin composite is lost during the finishing and polishing processes^{22,23}. On the best author's knowledge no study has performed to analyzed the effect of the posterior bulk fill resin composite preparation method for KHN and DC calculation influenced by LCU design in simulated mouth with limited mouth opening. Therefore, the aim of this study was to evaluate the effect of the sample preparation of bulk fill posterior resin composite in second molar teeth, prepared in a manikin with a limited mouth opening, on Knoop hardness and degree of conversion tests. The null hypotheses were: 1) The sample preparation method would have no influence on the Knoop hardness and the degree of conversion of the bulk fill restorations; and

2) The light curing unit would have no influence on the Knoop hardness and the degree of conversion of the bulk fill restorations.

METHODS AND MATERIALS

Study design

Two molar teeth were used, one was embedded through the conventional method and for the other one a new method was used (tripartite matrix with highly polished surface). In both teeth a class II mesio-occusal-distal (MOD) cavity was prepared with proximal boxes. All the restorations were performed with a high viscosity bulk fill composite: Opus Bulk Fill APS (FGM Dental Products, Joinville, SC, Brazil), and two light curing units (LCU): VALO Cordless (Ultradent, South Jordan, UT, USA), and Bluephase G2 (Ivoclar Vivadent, Schaan, Liechtenstein). All the samples were cured in the mouth opening extension device to simulate the buccal opening extension. Therefore, 3 groups were determined by the polishing process required for the hardness and degree of conversion tests (n=5). The groups are: 1) InPol: embedded and polished; 2) Pol: not embedded but polished; 3) SPOL: not embedded nor polished. The groups InPol and Pol are originated from the teeth prepared through the conventional method, and the group SPol came from the teeth prepared through the new method.

Development of a buccal opening simulation device

Intending to make the laboratory environment resemble the clinical restorative conditions when manipulating the resin composite and the light-curing process, a device was developed to simulate mouth opening. A dental manikin (MOM, Marília, São Paulo, Brazil) was modified by cutting off the area of interest, mandibular second molar region, creating the space to insert cylinder of polystyrene resin (Cristal, Piracicaba, SP, Brazil) with molar tooth. The prepared tooth was enabled to have proximal contact with its adjacent tooth (Figure 1C). Adaptation of screws was made to fix and stabilize the resin cylinders in the correct position (Figure 1B). The dental manikin was positioned in a dental patient simulator (MOM, Marília, São Paulo, Brazil) which was also adapted for interincisal opening extension regulation (Figure 1D). All restorations were light-cured with the tooth positioned in the second mandibular molar region simulating the 44 mm interincisal distance, which correspond a 12-year-old adolescent dimension¹⁷ (Figure 1D).

Cavity preparation and inclusion

For the conventional method the molar tooth was embedded in acrylic resin (Dencrilay, Dencril, Pirassununga, SP, Brazil), in red color to avoid light dissipation while light-curing, 2 mm below the cemento-enamel junction²⁴ (Figure 2). In order to set a standard class II MOD cavity preparation, a cylindrical round diamond bur #3146 (KG Sorensen, Barueri, SP, Brazil) was used in high-speed (Kavo do Brasil, Joinville, SC, Brazil) and under copious irrigation. The preparations were made in specimens with 4/5 of the intercuspal width in an expulsive shape of 6 degrees with 4.0 mm of occlusal-cervical depth from the central sulcus of each tooth, and the proximal box with 2.0 mm of extension and 1.0 mm depth, resulting in total depth of 5.0mm. The measures were standardized by the use of the standardization machine of *in vitro* preparations²⁵.

For the new method of the sample preparation, a tripartite matrix was developed using an extracted second mandibular molar tooth enabling easy removal of the restoration by separating the parts of the matrix after

the light-curing process²⁶(Figure 2). For this method the molar tooth was totally embedded in chemically activated red acrylic resin cylinder (Dencrilay, Dencril, Pirassununga, SP, Brazil) and then sectioned in three parts (buccal, middle, and lingual). The tripartite matrix was molded with addition silicone (Scan Putty Regular, Yllar, Pelotas, RS, Brazil) in order to record the mesial and distal anatomy of the middle third to create the contact point. In the middle third part of the tooth, MOD cavity preparation was made using the same parameters described for conventional method. The buccal and lingual parts of the matrix had their faces polished using silicon carbide abrasive paper of decreasing grit (#1200, 1500, 2000 and 2500, Norton, Campinas, SP, Brazil) and then polished with diamond pastes (6; 3; 1; 0.25 µm; Arotec, São Paulo, SP, Brazil) with their corresponding felt discs. All the three parts were then joined allowing the creation of the MOD restorations that can be easily removed by separating the thirds (Figure 2).

Restorative procedure

A bulk fill high viscosity resin composite (Opus Bulk fill APS, FGM, Joinville, SC, Brazil) and two broad-spectrum multipeak LCUs: VALO Cordless (Ultradent, South Jordan, UT, USA) and Bluephase G2 (Ivoclar Vivadent, Schaan, Liechtenstein) were used. The irradiance (mW/cm²) and emission spectrum (nm) delivered by the LCUs were measured using the MARC Resin Calibrator (BlueLight Analytics, Halifax, NS, Canada) 5 times per LCUs. The LCU tip diameter were measured using digital calliper (Mitutoyo, Mississauga, ON, Canada). The bulk fill resin was placed in a single increment (maximum of 5 mm depth). The LCU was positioned 1 mm above the

occlusal surface and the resin composite was light-cured for 40 seconds in the occlusal-mesial and 40 seconds in occlusal-distal regions of the occlusal surface. The light curing process was performed in a dark room with yellow light in order to avoid any possible light interference in the composite resin polymerization process. No adhesive application was used due to the fact that it would enable the removal of the resin composite sample from the restorative cavity. The restorations were removed and stored in a dark environment at 37 ° C for 24h.

Preparation of the samples for hardness test (n = 5)

The restorations were prepared following the three groups:

CEmPol Group, were embedded in polystyrene resin (Cristal, Piracicaba, SP, Brazil). Prior to testing, the surfaces were finished with silicon-carbide paper (#1200, 1500, 2000, and 2500 grit sizes; Norton, Campinas, SP, Brazil) followed by ultrasound in distilled water for 5 minutes, and polished with metallographic diamond pastes (6-, 3-, 1-, and 1/4- μ m sizes; Arotec, São Paulo, SP, Brazil).

CPol Group, was not embedded in polystyrene resin, being directly submitted to the polishing process as described for the CEmPol Group and fixed using cyanoacrylate (Super Bonder Loctite, São Paulo, SP, Brazil) on a glass cover slip.

PrePol Group, the samples made through the new method²⁶ were not polished nor embedded in polystyrene resin, and they were only removed from the tooth matrix and stabilized with cyanoacrylate on a histologic glass slide. The polishing of the surfaces was indirectly obtained by the polishing performed on the buccal and lingual walls of the tooth matrix.

Knoop microhardness test (KHN)

Knoop indentations (Shimadzu HMV 2000; Shimadzu Corporation; Kyoto, Japan) using 500g for 10s were made every 1.0 mm from the gingival and pulpal wall of the restorations, resulting in 5 and 4 indentations at proximal and occlusal regions respectively (Figure 3A).

Degree of conversion (%)

The degree of conversion (DC) in the mesial and distal proximal boxes were evaluated in 2 spots (2 mm distance from each measurement, Figure 3B) using LabRam HR Evolution Raman spectrometer (Horiba LabRam, Villeneuve d'Ascq, France). From the Raman vibrational modes, the area of peaks: aliphatic (1638 cm^{-1}) and aromatic (1608 cm^{-1}) were calculated from polymerized (P) and unpolymerized (NP) bulk fill composite samples. The formula for calculating the degree of conversion was: $\text{DC (\%)} = (1 - \text{P} / \text{NP}) \times 100$.

Statistical analysis of data

The KHN and DC values were tested for normal distribution (Shapiro–Wilk) and equality of variances (Levene test), followed by parametric statistical tests. Data was analyzed using two-way repeated measurement ANOVA and multiple comparisons were made using the Tukey test. All tests employed a 0.05 level of statistical significance and were performed using the statistical software Sigma Plot version 13.1 (Systat Software Ins, San Jose, CA, USA).

RESULTS

LCU characterization

The mean and standard deviation of irradiance values (mW/cm²) for VALO Cordless was 1297.9 ± 3.3 and Bluephase G2 was 1393.8 ± 4.5. The wavelength (nm) for VALO Cordless ranged between 395-480 and Bluephase G2 between 385-515. Each restoration received 51.9 J for VALO Cordless, and 55.8 J for Bluephase G2 on each region: occlusal/mesial and occlusal/distal.

Knoop hardness – KHN (N/mm²)

The KHN mean and standard deviation values of the two LCUs for each method of sample preparation at various restoration depths are presented in Figure 4. ANOVA two-way repeated measurement demonstrated significant influence for sample confection method ($P < 0.001$), depth of restoration ($P < 0.001$) and for interaction between sample confection method and depth of restoration ($P = 0.003$). However, no significant influence for LCU ($P = 0.475$), neither for interaction between sample confection method and LCU ($P = 0.734$), LCU and depth of restoration ($P = 0.700$); and also, for interaction among sample confection method, LCU and depth of restoration ($P = 0.766$). The KHN values in general reduced significantly from the top to the bottom of the restoration, mainly at proximal boxes. The PrePol method was the method more efficient to detect the significant difference for depth of the restoration and tooth region.

Degree of Conversion - DC (%)

The DC mean and standard deviation values of the two LCUs for each method of sample preparation at various restoration depths are presented in Figure 5. ANOVA two-way repeated measurement demonstrated significant influence for sample confection method ($P < 0.001$), tooth region ($P < 0.001$), and for interaction between sample confection method and tooth region ($P = 0.002$). However, no significant influence for LCU ($P = 0.317$), sample confection method LCU and tooth region ($P = 0.344$), LCU and tooth region ($P = 0.314$), sample confection method,

LCU and tooth region ($P=0.454$). The DC values were significantly lower on the gingival region on the proximal box of than the measurements made on the top of the restoration, irrespective of the local if at mesial, occlusal or distal area. The DC measured on the gingival region on the proximal box of the measurements made on the top of the restoration for PrePol method was lower than the other methods. The KHN and DC results presented similar performance for all tested experimental conditions.

DISCUSSION

The present study found that the sample preparation method influenced on the KHN and DC, therefore the first null hypothesis was rejected. The type of light curing unit had no significant influence on these parameter, thus the second hypothesis was accepted.

In vitro studies usually, perform restorations under ideal conditions meaning that no limitation of mouth opening or any difficulties on placing the LCU.^{22,27} The correct positioning of the LCU is an important rule on the curing light process for well succeed restoration¹³. However, in clinical procedures this procedure is often misaligned while performing a restoration in posterior teeth²¹. For this reason, the buccal opening devise developed in the present study aimed to simulate the clinical condition, which can impose challenge for LCU position during restorations performed in molar teeth.

A usual method to assess the hardness of a composite resin is the indentation equipment, which requires a flat and well-polished surface. For this reason, the samples are frequently embedded and polished prior to the hardness assessment²². To sample embedded, a usual material is the polystyrene resin which has exothermic polymerization reaction. The issue that comes up with this technique is that by being an exothermic material, it may cause hit on the sample increasing the polymerization reaction of the composite resin^{28,29}. For this reason, the tested groups CPol and PrePol, intended to represent the sample without the interference of external hit coming from the exothermic reaction of the polystyrene resin. Studies have shown that increasing temperature by preheating the composite resin does not increase the degree of conversion of the material³⁰⁻³². The present study found that the increase of temperature caused by the exothermic reaction generate by polystyrene resin was sufficient to detect significative differences on the degree of conversion and Knoop hardness of the bulk fill resin tested. It is important to consider that different brands of bulk fill resins have different chemical composition which may interfere in this result for different brands. Another issue is that in order to obtain a flat and polished surface, the sample require a polishing procedure, which leads to the removal of the superficial layer that contains non reacted

monomers resulting in hardness data that do not reflect the clinical condition considering that the superficial layer lost may have different mechanical properties from an internal layer. In this study, the DC on the gingival region on the proximal boxes of the restoration of PrePol method was lower than the other methods, certainly because unpolymerized monomers were removed during the polishing process.

A literature review of the clinical studies between 1996 to 2011, 90% indicated failure rates between 1% and 3% for Class I and Class II restorations made in composite resins³³. The main reason for failure includes secondary caries and tooth fracture^{33,34}. KHN and DC are important mechanical properties that should be carefully considered in Class II restorations in molar teeth due to the high failure risk^{35,36}, once low values for KHN and DC represent the presence of unpolymerized resin composites³⁷, leading to a higher risk of premature failure of the restoration³⁸. Multi-faced restorations are shown to have a shorter longevity when compared to single faced surfaces of resin composite restorations³³. Not only the quantity of surfaces involved, but also the cavity size and type of restorations are related to failure risk³³. The gingival floor at proximal box receives less irradiance from the LCU than the occlusal area due to an increased distance of the LCU tip and the tip inclination³⁹. Shadows are created in the proximal boxes due to adjacent teeth and inclination of the LCU tip, which limit the irradiance and energy that reach deeper areas at gingival floor.

The KHN and DC testes should be performed in a standardized post-cured time, once the restorations do not develop their final mechanical properties immediately after curing⁴⁰. It was possible to notice that KHN and DC values in general reduced significantly from the top to the bottom of the restoration, mainly at proximal boxes, which rises up the concern of having a premature failure in those areas due to lack of ideal polymerization. Although the bulk fill composites reduce the chair time, the effectiveness of the adequate curing along the depth of the restoration may result in lower mechanical properties presented in some areas compared to a highly filled nano-hybrid composite²⁷.

Different methods are used to prepare the samples for KHN and DC tests, most of them including the sample preparation under condition with no limitation of technique such as light-curing the material in a Teflon mold²⁷ or in silicon mold between two polyester strips⁴ with no LCU tip positioning difficulties. In this study the interincisal distance was settled at 44 mm representing children on the age between 12 and 14 years old¹⁷. The use of a patient simulator with controllable opening distance resembling the restriction of the LCU tip being well positioned due to the mouth opening and presence of upper teeth intended to enable further studies to also represent better the

clinical reality. As shown by the results, the interincisal distance of 44 mm was not able to impair both LCUs tested in this study. Bluephase G2 that has curved tip and Valo Cordless a straight design showed similar KHN and DC results. Therefore, for the mouth opening distance used in this study both of the LCU show predicable results, which may not be true when it comes to a patient who presents a facial morphology on mandibular range of motion, being required further studies.

Two multi-peak LED LCU with different design were used to clarify how the tip shape and angulation factors considered for LCU selection when curing RBC's, especially in areas where the tip positioning could be hampered. In a recent study comparing 22 contemporary light curing units¹⁵, it was evidenced some important aspects to be analyzed in different LCU including tip positioning that could be poorly positioned on posterior teeth due to the tip angulation. For further studies, the evaluation of restorations performed in the patient simulator with a mouth opening under 44 mm, representing a child or a patient with facial morphology on mandibular range of motion is suggested, to assess the difficulty due to the LCU design and angulation.

CONCLUSION

Within the limitations of this in vitro study, it is possible to conclude that the sample preparation that was embedded and polished resulted in elimination of the difference among KHN and DC values of bulk fill composite restorations influenced by depth or region of the cavities, probably because the additional heating caused by polystyrene resin and also by removal of uncompleted polymerized monomers layer removed due to the polishing process. The use of PrePol method was able to detect difference produced by light activation in deeper areas. In the buccal opening of 44 mm no relevant difference was found between Valo Cordless and Bluephase G2.

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FIGURES

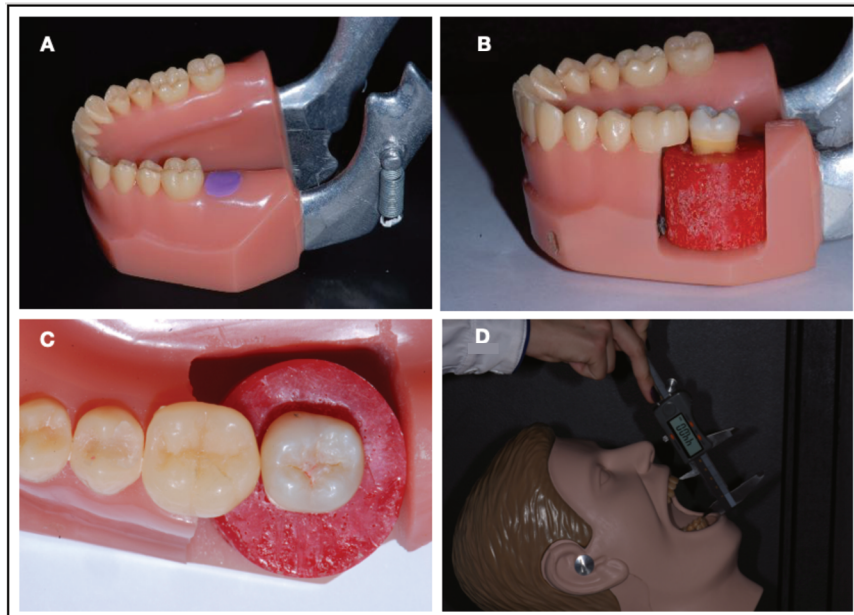


Figure 1. Development of buccal opening simulation device: (A) Manikin with impression material filling up teeth second mandibular molar alveoli. (B) Manikin adapted to hold a cylinder sample (C) Sample showing its contact point (D) Interincisal distance of a 12-year-old adolescent (44mm).

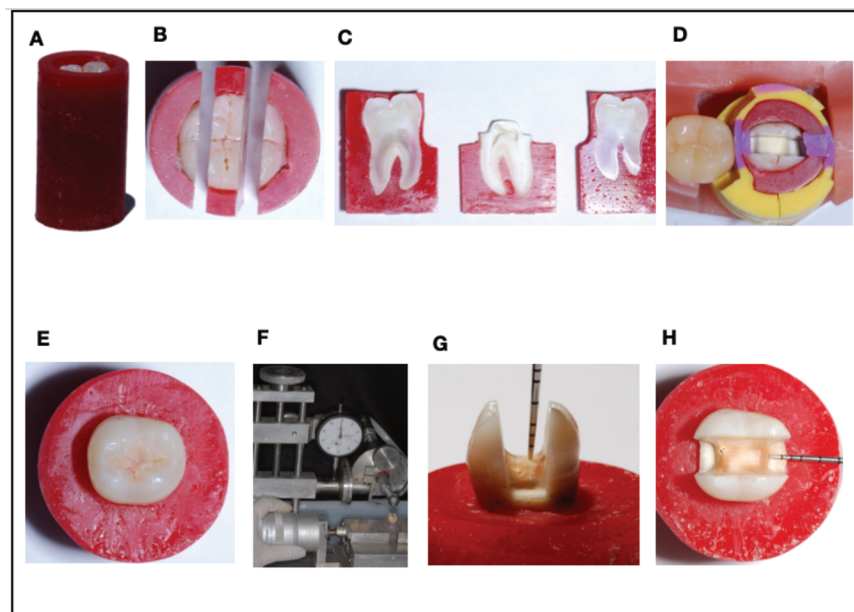


Figure 2. Tripartite matrix: (A) Molar tooth totally embedded in chemically activated red acrylic resin (B) Molar tooth sectioned in 3 parts (buccal, middle, and lingual) (C) View of the buccal, middle, and lingual parts. Middle third with no resin in the coronal third (D) Sample showing its contact point. Conventional matrix: (E) Molar tooth embedded in chemically activated acrylic resin in red colour (F) Cavity preparation on the standardization machine of *in vitro* preparations (G) Proximal boxes with total of 5mm depth (H) Overhead view of the sample.

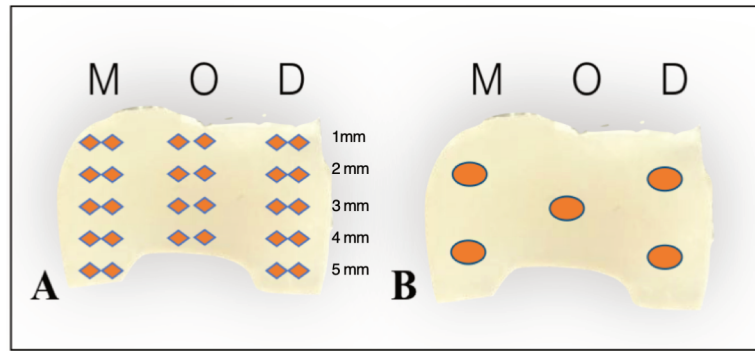


Figure 3. Tests performed: (A) Knoop hardness indentations spots. (B) Degree of conversion measurement spots.

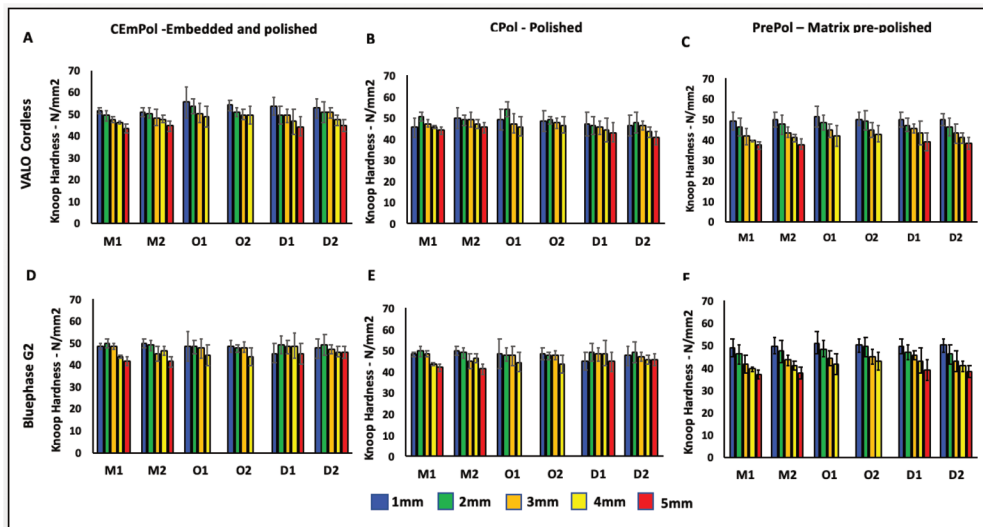


Figure 4. Means and standard deviation of Knoop hardness test (N/mm²) performed (n=5) showing the three different sample preparation method and the two LCU used comparing light-curing in different depts.

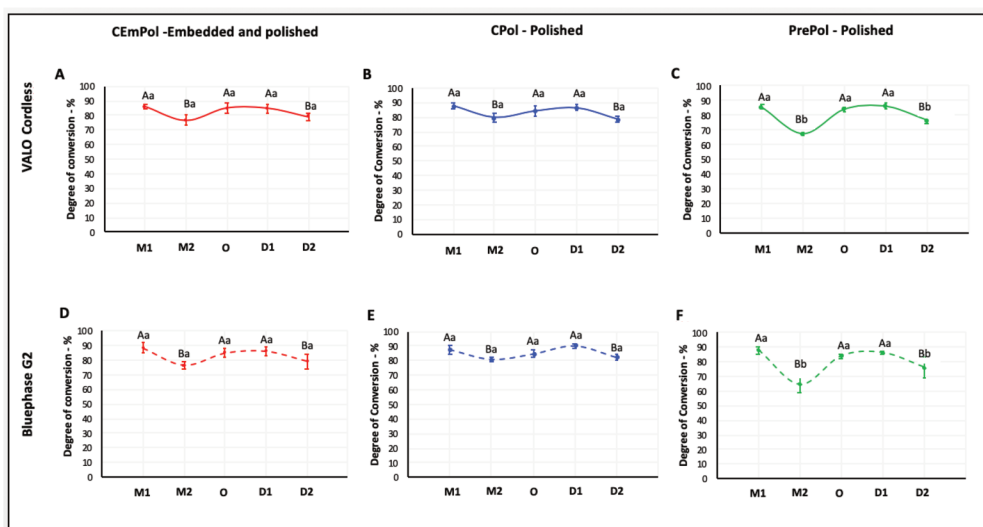
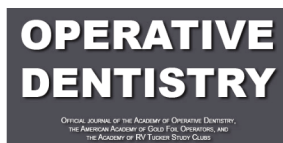


Figure 5. Means and standard deviation of Degree of Conversion (%) performed (n=5) showing the three different sample preparation method and the two LCU used comparing light-curing in different depts.

Appendix: 1- Normas da Revista



New Instructions as of 20 September 2008

Operative Dentistry requires electronic submission of all manuscripts. All submissions must be sent to Operative Dentistry using the [Allen Track upload site](#). Your manuscript will only be considered officially submitted after it has been approved through our initial quality control check, and any problems have been fixed. You will have 6 days from when you start the process to submit and approve the manuscript. After the 6 day limit, if you have not finished the submission, your submission will be removed from the server. You are still able to submit the manuscript, but you must start from the beginning. Be prepared to submit the following manuscript files in your upload:

- A Laboratory or Clinical Research Manuscript file must include:
 - a title
 - a running (short) title
 - a clinical relevance statement
 - a concise summary (abstract)
 - introduction, methods & materials, results, discussion and conclusion
 - references (see Below)
 - The manuscript **MUST NOT** include any: identifying information such as: Authors, Acknowledgement, Correspondence information, Figures, Graphs, Tables.
 - An acknowledgement, disclaimer and/or recognition of support (if applicable) must in a separate file and uploaded as supplemental material.
- All figures, illustrations, graphs and tables must also be provided as individual files. These should be high resolution images, which are used by the editor in the actual typesetting of your manuscript. Please refer to the instructions below for acceptable formats.
- All other manuscript types use this template, with the appropriate changes as listed below.
- **FOR ALL MANUSCRIPTS**
- 1. **CORRESPONDING AUTHOR** must provide a WORKING / VALID e-mail address which will be used for all communication with the journal.
NOTE: Corresponding authors **MUST** update their profile if their e-mail or postal address changes. If we cannot contact authors within seven days, their manuscript will be removed from our publication queue.
- 2. **AUTHOR INFORMATION** must include:
 1. full name of all authors
 2. complete mailing address for each author
 3. degrees (e.g. DDS, DMD, PhD)
 4. affiliation (e.g. Department of Dental Materials, School of Dentistry, University of Michigan)
- 3. **MENTION OF COMMERCIAL PRODUCTS/EQUIPMENT** must include:
 1. full name of product
 2. full name of manufacturer

3. city, state and/or country of manufacturer

4. **MANUSCRIPTS AND TABLES** must be provided as Word files. Please limit size of tables to no more than one US letter sized page. (8 ½" x 11")
5. **ILLUSTRATIONS, GRAPHS AND FIGURES** must be provided as TIFF or JPEG files with the following parameters

1. line art (and tables that are submitted as a graphic) must be sized at approximately 5" x 7" and have a resolution of 1200 dpi.

- gray scale/black & white figures must have a minimum size of 3.5" x 5", and a maximum size of 5" x 7" and a minimum resolution of 300 dpi and a maximum of 400 dpi.
- color figures must have a minimum size of 2.5" x 3.5", and a maximum size of 3.5" x 5" and a minimum resolution of 300 dpi and a maximum of 400 dpi.
- color photographs must be sized at approximately 3.5" x 5" and have a resolution of 300 dpi.

• **OTHER MANUSCRIPT TYPES**

1. **CLINICAL TECHNIQUE/CASE STUDY MANUSCRIPTS** must include:

- a running (short) title
- purpose
- description of technique
- list of materials used
- potential problems
- summary of advantages and disadvantages
- references (see below)

2. **LITERATURE AND BOOK REVIEW MANUSCRIPTS** must include:

- a running (short) title
- a clinical relevance statement based on the conclusions of the review
- conclusions based on the literature review...without this, the review is just an exercise
- references (see below)

- **REFERENCES** must be numbered (superscripted numbers) consecutively as they appear in the text and, where applicable, they should appear after punctuation.

- The reference list should be arranged in numeric sequence at the end of the manuscript and should include:

- 1. Author(s) last name(s) and initial (ALL AUTHORS must be listed) followed by the date of publication in parentheses.
- 2. Full article title.
- 3. Full journal name in italics (no abbreviations), volume and issue numbers and first and last page numbers complete (i.e. 163-168 NOT attenuated 163-68).
- 4. Abstracts should be avoided when possible but, if used, must include the above plus the abstract number and page number.
- 5. Book chapters must include chapter title, book title in italics, editors' names (if appropriate), name of publisher and publishing address.
- 6. Websites may be used as references, but must include the date (day, month and year) accessed for the information.
- 7. Papers in the course of publication should only be entered in the references if they have been accepted for publication by a journal and then given in the standard manner with "In press" following the journal name.
- 8. **DO NOT** include unpublished data or personal communications in the reference list. Cite such references parenthetically in the text and include a date.