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BERTHYELLE PÁDOVA NYLAND

EFEITO DE BIOVIDROS NA REMINERALIZAÇÃO DO ESMALTE SUBMETIDO À EROSÃO DENTAL

Curitiba
2015

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Dissertação apresentada ao Programa de Pós-Graduação em Odontologia da Pontifícia Universidade Católica do Paraná, como parte dos requisitos para obtenção do título de Mestre em Odontologia, Área de Concentração em Dentística.

Orientador: Prof Dr. Sérgio Vieira
Coorientadora:Prof Dra. Andrea Freire

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Curitiba, 10 de abril de 2015.

“A mente que se abre a uma nova idéia jamais voltará ao seu tamanho original.”
Albert Einstein

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SUMÁRIO

ARTIGO EM PORTUGUÊS

Página Título

Título: Efeito de biovidros na remineralização do esmalte submetido à erosão dental

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Resumo

Objetivo: Avaliar *in vitro* o efeito de biovidros experimentais no processo de remineralização do esmalte dental submetido ao desafio ácido. Materiais e métodos: Para este trabalho foram utilizados 35 terceiros molares cortados em cortadeira metalográfica com disco diamantado obtendo fragmentos de esmalte 3X3 mm que foram inlcuídos em resina acrílica, desgastados e polidos. Os espécimes foram divididos em 7 grupos: G1- água, G2- Elmex®, G3- Biovidro 45S5, G4- Biovidro experimental PCNSr, G5- Biovidro experimental PCNSrTi, G6- Biovidro experimental PCNSrMg, G7- Sem tratamento. Os espécimes passaram por ciclos erosão/remineralização que consistiam na aplicação de 0,3% de ácido cítrico por 2 minutos, lavagem em água deionizada por 1 minuto e aplicação da substância remineralizante por 3 minutos, 2 vezes ao dia por 9 dias. Após o período experimental foram realizados os testes de microscopia eletrônica de varredura, espectroscopia dispersiva de raios X, difração de raios X, espectroscopia Raman e microdureza Knoop nas profundidades 20 µm,45 µm,70 µm e 100 µm. Resultados: No teste de microdureza todas as substâncias remineralizantes apresentaram maior dureza comparado ao G1 ($p<0,05$) e semelhança estatística comparado ao G7. Nos testes de DRX e Raman os grupos que apresentaram maior intensidade de picos de hidroxiapatita e fosfato foram, em ordem decrescente: G3-G6-G5-G4-G2-G1. As imagens obtidas por MEV mostraram padrão de esmalte condicionado nos grupos 1 e 4, diferente dos demais grupos. Significância: Dentre os biovidros experimentais estudados os biovidros compostos por PCNSrMg e PCNSrTi apresentaram potencial remineralizante consistente em todos os testes utilizados.

Palavras-chave: biovidro, erosão dental, remineralização, dureza, esmalte dental

Introdução

A erosão dental envolve mudanças na estrutura dentária, e está relacionada com alterações nas propriedades mecânicas e físicas do dente, as quais são ocasionadas pela perda mineral [1,2]. No esmalte é inicialmente manifestada como uma desmineralização parcial da superfície, o que leva ao amolecimento da mesma [3,4]. Se a erosão persistir há dissolução de consecutivas camadas de cristais de hidroxiapatita levando à perda permanente de volume e, em estágios mais avançados ocorre a exposição dentinária [1].

Uma vez que a erosão dental é resultado da exposição à ácidos, extrínsecos ou intrínsecos, para prevenir ou conter o processo erosivo o ideal seria diminuir ou evitar o contato com o ácido. Entretanto é impossível evitar este contato durante toda a vida [1,5,6]. Desta forma, o diagnóstico precoce bem como o desenvolvimento de substâncias que reduzam a desmineralização ou propiciem a remineralização [7-10] faz-se necessário para a abordagem da erosão dental, que já pode ser considerada um fator de risco para saúde bucal [11]. A prevalência de erosão dental em dentes permanentes de crianças e adolescentes foi considerada alta, podendo variar de 25,1% no Brasil, 39,8% nos E.U.A., 50% no Reino Unido e 51,6% na Grécia [12]. A alta prevalência na maioria dos países foi relacionada à dieta ácida, ou seja , erosão de origem extrínseca.

Estratégias utilizadas para evitar ou reduzir o processo erosivo incluem a utilização de substâncias como flúor [11,13-15] e outros produtos que atuam na remineralização [8,15,16]. Dentre as formas de fluoretos, o estanoso propicia maior efeito contra a desmineralização e desta forma permite menor perda mineral [13,14,17]. Atualmente, substâncias bioativas são empregadas na odontologia para induzir a remineralização, dentre estes pode-se destacar o ACP-CPP (fosfato de cálcio amorfo estabilizado por fosfopeptídeo de caseína) [9,16], Novamin® (Biovidro 45S5) [8,18,19] e o silicato de cálcio e fosfato [4,6]. Estas substâncias bioativas têm a capacidade de prover cálcio e fostato para a superfície erodida e assim, reduzem a perda mineral e permitem a remineralização [8,19]. O ACP-CPP é empregado em produtos odontológicos disponíveis comercialmente como pasta dental [9,16], clareadores dentais [20,21] e materiais restauradores [22].

O Novamin® apresenta na sua composição o biovidro 45S5, que foi o primeiro a ser desenvolvido e demonstra sucesso nas aplicações clínicas, inclusive na área odontológica [7,19,23-25], sendo incorporado a diferentes materiais como cremes dentais [19], materiais para profilaxia [26], clareadores dentais [27] e resinas compostas [28].

No entanto, ainda não existe um consenso na literaura sobre o efeito cumulativo da sílica no organismo [29]. Sendo assim, o desenvolvimento de novos materiais bioativos, sem a presença de sílica, torna-se um assunto de interesse na área odontológica. Nesta abordagem de novos materiais, recentemente foi desenvolvido um biovidro sem sílica, a base de fosfato de cálcio e estrôncio modificado pela presença do magnésio ou titânio [30].

O estrôncio é empregado na odontologia desde 1950, principalmente para o tratamento da hipersensibilidade dentinária [31]. Este elemento mostra-se fortemente adsorvido aos tecidos calcificados como esmalte e dentina [31,32] e pode ser adicionado aos vidros fosfatos, porém, aumenta sua taxa de degradação [33]. Para reduzir este problema, foi observado que a adição de óxido de titânio e de magnésio reduz a solubilidade sem comprometer a bioatividade [30,34].

Desta forma, há necessidade de avaliar a eficácia na odontologia do biovidro a base de fosfato de cálcio e estrôncio, com a solubilidade controlada pela adição de óxidos de titânio ou magnésio.

O objetivo deste estudo *in vitro* foi avaliar o efeito de biovidros experimentais no processo de remineralização do esmalte dental submetido ao desafio ácido. As alterações químicas e morfológicas na superfície do esmalte foram avaliadas qualitativamente por difração de raios X (DRX), espectroscopia Raman, Microscopia eletrônica de varredura (MEV) e espectroscopia de energia dispersiva de raios-X (EDS). A hipótese nula a ser testada foi que não haveria diferença com relação à perda mineral do esmalte com a utilização de diferentes substâncias remineralizantes.

Materiais e métodos

Preparo dos Espécimes

Para a pesquisa foram utilizados 35 dentes humanos, terceiros molares extraídos, obtidos após parecer positivo do Comitê de Ética em Pesquisa. Os dentes foram cortados com a utilização de um disco diamantado em cortadeira metalográfica (Struers A/S, Ballerup, Denmark) sob irrigação constante, obtendo fragmentos de esmalte com 3 x 3 x 2 mm da face vestibular. Os espécimes foram incluídos em resina acrílica, em seguida desgastados com lixa de carbeto de silício nas granulações #800, # 1000, #1200 (3M do Brasil, Sumaré, SP, Brasil) e polidos com disco de feltro e óxido de cério em politriz (Buehler Ltda, Lake Bluff, IL, E.U.A.). Após o polimento os espécimes foram observados em microscópio óptico com aumento de 50x (Olympus, São Paulo, SP, Brasil) para verificar a presença de esmalte em toda a extensão e também permitir uma padronização dos espécimes. Foram utilizados 35 espécimes obtidos da face vestibular dos dentes edivididos em 7 grupos (n=5) de acordo com a substância a ser aplicada posteriormente ao desafio erosivo (Tabela 1).

Desafio Erosivo

Para o desafio erosivo foi utilizada uma solução 0,3% de ácido cítrico com pH de 3,2 ajustado com hidróxido de sódio. Cada espécime recebeu a aplicação de 1mL desta solução sob agitação em um período de 2 minutos, sendo 1mL aplicados a cada minuto. Foram realizadas 2 aplicações por dia, durante 9 dias. Após o desafio erosivo os espécimes foram lavados com 5 mL de água deionizada em ultrassom por 1 minuto.

Aplicação das Soluções Remineralizantes

Na sequência, uma solução remineralizante foi aplicada de acordo com a Tabela 1. Os grupos dos biovidros utilizaram a solução com 1 g de biovidro em 5 mL de água deionizada, sendo 1 mL por espécime e armazenados em estufa 37° durante 3 minutos. Entre os ciclos erosão/remineralização os espécimes foram armazenados em umidade relativa a 37°. O G7 não sofreu desafio erosivo e nem aplicação de substância remineralizante e, desta forma, foi utilizado para comparação com os resultados dos demais grupos.

Tabela 1: Descrição dos grupos de acordo com a solução remineralizante a ser utilizada e sua composição

Grupos	SoluçõesRemineralizantes	Composição
G1	Água deionizada (controle negativo)	---
G2	Cloreto estanoso, fluoreto de amina e fluoreto de sódio (Elmex®)	800 ppm Sn^{2+} na forma de cloreto estanoso, 125 ppm F^- amina, 350 ppm F^- fluoreto de sódio
G3	Biovidro comercial 45S5	45%SiO_2, 24,5%Na_2O e CaO e 6% P_2O_5
G4	Biovidro experimental PCNSr	40%P_2O_5, 30%CaO, 25% Na_2O, 5%SrO
G5	Biovidro experimental PCNSrTi	40%P_2O_5, 30% CaO, 20% Na_2O, 5% SrO, 5% TiO_2
G6	Biovidro experimental PCNSrMg	40%P_2O_5, 30% CaO, 20% Na_2O, 5% SrO, 5% MgO
G7	Controle posivito (sem tratamento)	---

Confecção dos biovidros

Os biovidros experimentais foram confeccionados a partir da metodologia descrita por Weiss et al. [30], e o biovidro comercial 45S5 utilizado como material de referência foi confeccionado segundo as informações do fabricante. A moagem foi realizada em um moinho de bolas de alta energia (Mixer mill 5100 – SPEX®SamplePrep, Metuchen, NJ, EUA). Dez gramas de biovidro foram moídas por vez, durante 8 horas e com uma velocidade de 455 rpm.

Difração de raios-X

Três espécimes de cada grupo foram analisados utilizando difração de raios-X (DRX7000, ShimadzuCorp.,Tóquio ,Japão) após os 9 dias de aplicação dos produtos. A intensidade de difração foi medida em cada espécime pela varredura com ângulo rasante (10 graus), na faixa de 20 a 80 graus, com radiação de CuK α, e velocidade de 1 grau por minuto. Após a obtenção dos gráficos foi feita a linha base dos espectros nos 4 picos mais intensos e então um ajuste matemático foi realizado utilizando a curva gaussiana com o software

FITYK e assim foi calculada a área. A soma da área dos picos mais intensos correspondentes a hidroxiapatita foi realizada, indicando qualitativamente a fração cristalina de hidroxiapatita na superfície.

Microscopia Eletrônica de Varredura (MEV) e Espectroscopia de energia dispersiva de raios-X (EDS)

Amostras representativas de cada grupo foram utilizadas para análise do conteúdo mineral do esmalte com um sistema detector de Raio-X acoplado a um MEV. No EDS os principais elementos analisados foram o Cálcio e o Fósforo. Para observar a superfície de esmalte após os ciclos erosão/remineralização foi realizada a microscopia eletrônica de varredura onde os espécimes foram metalizados por ouro e analisados com aumento de 1000X. A análise do tamanho médio das partículas de biovidro utilizadas neste estudo também foi feita por MEV.

Espectroscopia Raman

As medidas de espectroscopia Raman foram realizadas em dois espécimes por grupo no aparelho WITEC modelo alpha 300 (WITecInstrumentsCorp., Knoxville, TN). A excitação foi fornecida utilizando 13,8 mW por um laser vermelho (He-Ne) com comprimento de onda 632,8 nm e resolução do espectro de 0,02 cm^{-1}. Os espectros avaliados foram bandas de fosfato (comprimento de onda de 960 cm^{-1}) e os dados obtidos foram analisados pelo software WITec Project 2.08. Para análise dos dados obtidos a linha base dos espectros foi zerada e altura dos picos avaliada.

Microdureza Knoop

Previamente à análise de dureza os espécimes foram seccionados no centro com um disco diamantado em cortadeira metalográfica (Struers A/S, Ballerup, Denmark) sob irrigação constante e, em seguida desgastados com lixa de carbeto de silício (#1200 - 3M do Brasil, Sumaré, SP, Brasil) e polidos com disco de feltro e óxido de cério em politriz (BuehlerLtda, Lake Bluff, IL, E.U.A.).A avaliação da microdureza Knoop do esmalte foi realizada em microdurômetro (HMV-2T, ShimadzuCorp., Tóquio, Japão) com carga estática de 10 g por 10 s [38] . Foram realizadas 6 indentações espaçadas 25 μm entre elas e nas profundidades de 20 μm, 45 μm, 70 μm e 100 μm da superfície externa e, então a média das indentações para cada profundidade foi calculada [35].

Análise Estatística

Os dados foram submetidos à análise estatística e após a verificação da normalidade pelo teste Shapiro-Wilk e homogeneidade pelo teste Levene foi realizada Análise de Variância a dois critérios e comparações múltiplas pelo teste Tukey HSD. Todos os testes utilizaram nível de significância de 0,05.

Resultados

No DRX foi observado padrão semelhante à hidroxiapatita (padrão JCPDS 009-0432), e a soma da área dos picos mais intensos analisados indicou qualitativamente a presença de cristal sobre a superfície do esmalte após os tratamentos. Os grupos que apresentaram maior intensidade de picos de hidroxiapatita em ordem decrescente foram: Biovidro 45S5, PCNSrMg, PCNSrTi, PCNSr, Elmex e Água.

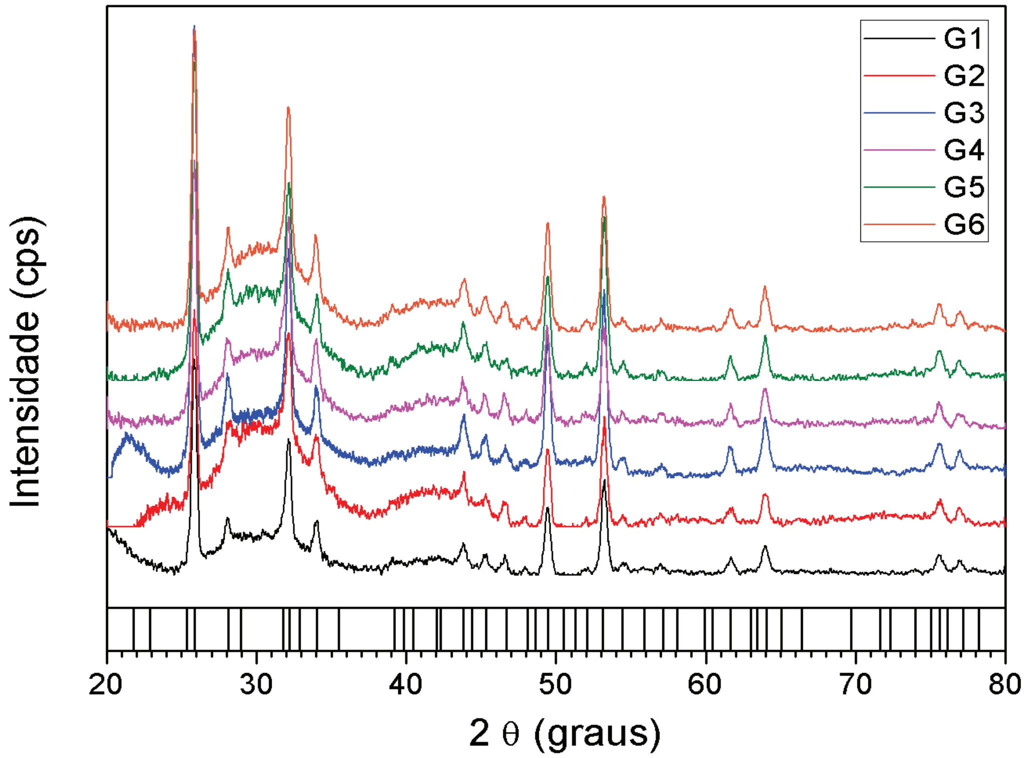
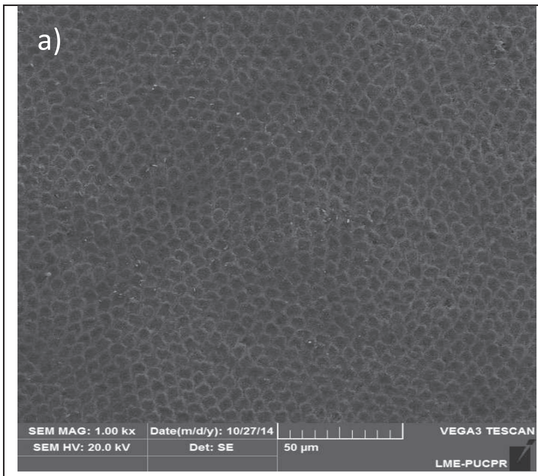
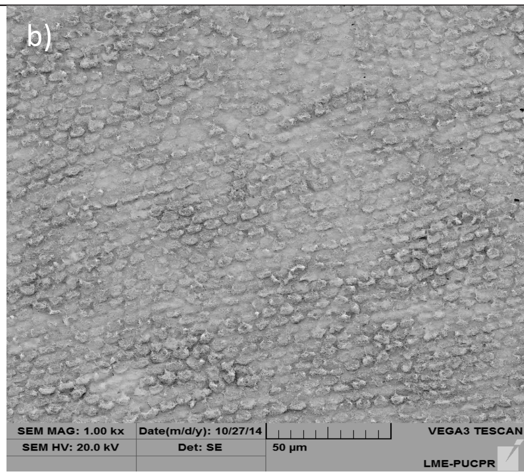


Fig. 1: Análise DRX da superfície de esmalte após o ciclo erosão/remineralização.

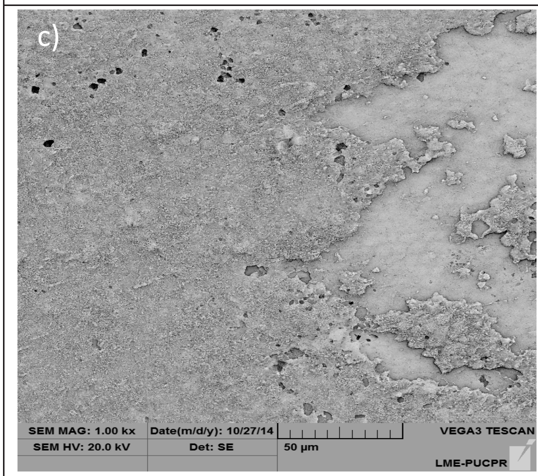
As imagens obtidas por MEV e os dados do EDS podem ser visualizados na Figura 2.



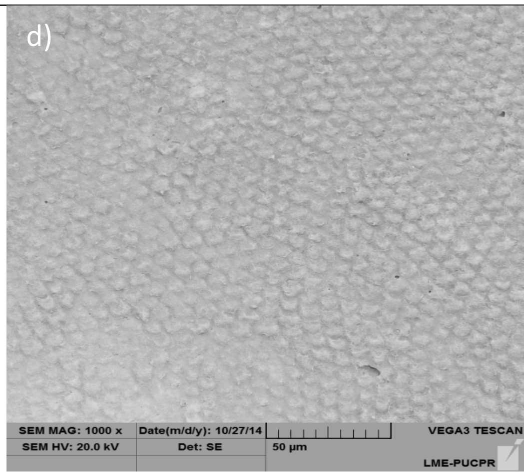
	Wt%
O	54.2
Ca	28.2
P	16.9
Na	0.7



	Wt%
O	42.2
Ca	34.7
P	15.8
Sn	5.8
Cl	0.7
Na	0.6
Si	0.3



	Wt%
O	46.0
Ca	33.3
P	16.0
Si	4.1
Na	0.6



	Wt%
O	41.3
Ca	38.7
P	19.1
Na	0.6
Sr	0.3

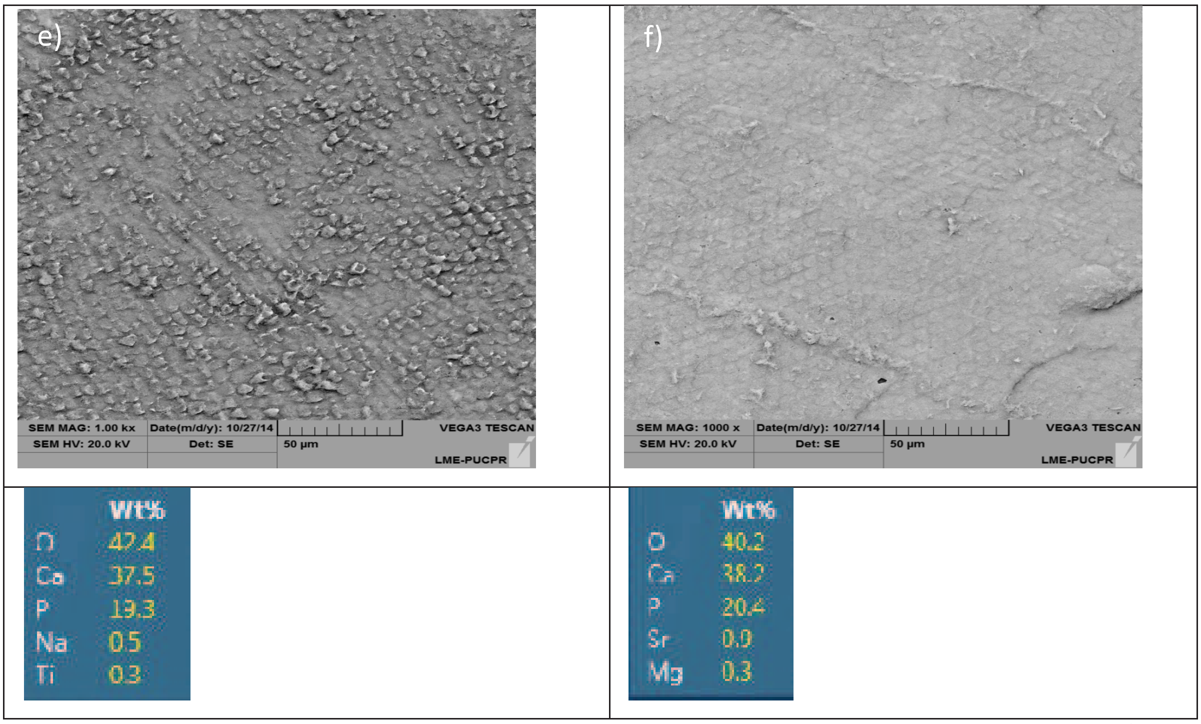


Fig. 2: Fotomicrografias obtidas por MEV com aumento de 1000X e 20KV e EDS da superfície do esmalte após o último ciclo de erosão/remineralização. a) Grupo 1 - controle negativo; b) Grupo 2 - Elmex ®; c) Grupo 3 - Biovidro 45S5; d) Grupo 4 - Biovidro experimental PCNSr; e) Grupo 5 - Biovidro experimental PCNSrTi ; f) Grupo 6 - Biovidro experimental PCNSrMg.

No EDS observamos que todos os grupos apresentaram Cálcio entre 28 e 38% em peso e Fósforo entre 15 e 21% em peso, e, após o período de erosão/remineralização nas imagens obtidas por MEV correspondentes aos grupos 2-3-5 e 6 (Fig 1 – b, c, e ,f) observa-se a deposição de substâncias sobre a superfície do esmalte, sendo mais intensa nos últimos três grupos. Entretanto as imagens referentes aos grupos 1 e 4 apresentam padrão semelhante e com aspecto de esmalte condicionado.

No teste de espectroscopia Raman os grupos que apresentaram picos de fosfato (960 cm^{-1}) mais intensos foram os que utilizaram os biovidros na mesma sequência dos resultados encontrados no teste de DRX: G3 – G6 - G5 –G4 – G2 – G1.

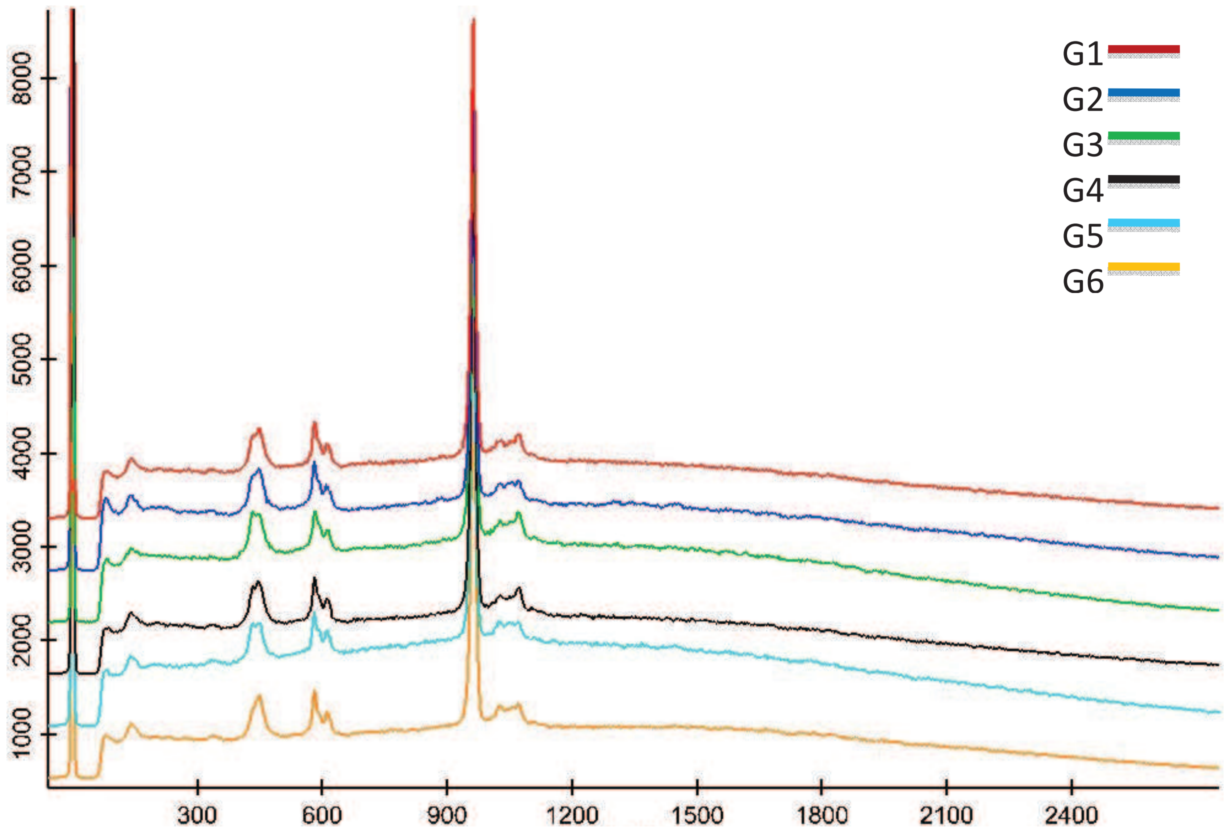


Fig 3: Espectros representativos da espectroscopia de Raman obtidos após os ciclos erosão/remineralização que caracterizam as bandas de fosfato 960 cm^{-1}.

Nos resultados obtidos a partir da microdureza Knoop, houve diferença significante com relação aos tratamentos ($p<0,05$) e não foi detectada diferença com relação às profundidades ($p=0,4821$). Entretanto, a interação entre tratamentos e profundidades foi significante ($p<0,05$). As diferenças estatísticas estão dispostas na Tabela 2 e Figura 4.

Tabela 2: Valores médios e desvio padrão da microdureza Knoop do esmalte com os materiais avaliados nas diferentes profundidades.

	GRUPO 1 Água	**GRUPO 2** ELMEX	**GRUPO 3** Biovidro 45S5	**GRUPO 4** Biovidro PCNSr	**GRUPO 5** Biovidro PCNSrTi	**GRUPO 6** Biovidro PCNSrMg	**GRUPO 7** Controle Positivo
20 µm	139,48(12,86)^{a}	234,91(9,60)^{b}	238,34(18,81)^{b}	230,86(13,11)^{b}	223,10(5,66)^{b}	226,40(17,48)^{b}	256,16(20,50)^{b}
45 µm	146,36(16,87)^{a}	239,31(5,50)^{b,d}	235,48(17,50)^{b,d}	237,14(13,24)^{b,d}	223,34(15,09)^{b,d}	219,66(6,37)^{b,c}	259,08(23,74)^{d}
70 µm	144,67(13,02)^{a}	245,27(7,10)^{b}	240,76(13,70)^{b}	230,04(13,53)^{b}	226,76(12,93)^{b}	237,56(15,97)^{b}	260,90(15,40)^{b}
100 µm	156,27(18,48)^{a}	255,06(7,77)^{b}	245,65(15,13)^{b}	235,50(17,18)^{b}	234,64(23,58)^{b}	247,64(17,56)^{b}	264,64(21,44)^{b}

*Letras diferentes indicam diferença estatística entre colunas ($p<0,05$) de acordo com o teste Tukey HSD.

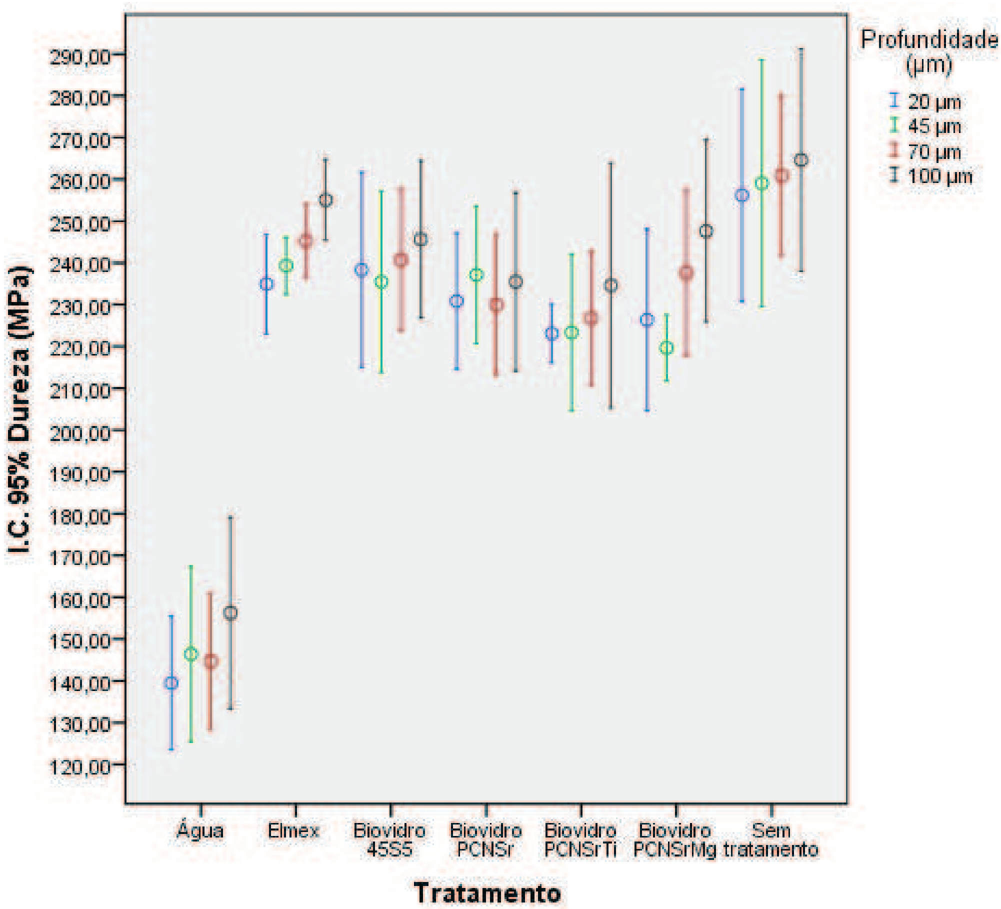


Fig. 4: Valores de microdureza knoop dos grupos avaliados de acordo com diferentes tratamentos e profundidades.

Os menores valores de microdureza foram encontrados no grupo que não utilizou nenhuma substância remineralizante (G1), sendo este diferente dos demais grupos ($p<0,05$). Enquanto que todos os grupos que empregaram substâncias remineralizantes apresentaram semelhança estatística com o grupo que não sofreu desafio ácido (G7), independente da profundidade ($p>0,05$), com exceção do grupo PCNSrMg na profundidade de 45 µm ($p=0,02$).

As partículas de biovidro utilizadas possuíam um tamanho médio de 14 µm e foram analisadas por MEV, sendo possível visualizá-las na Fig 5.

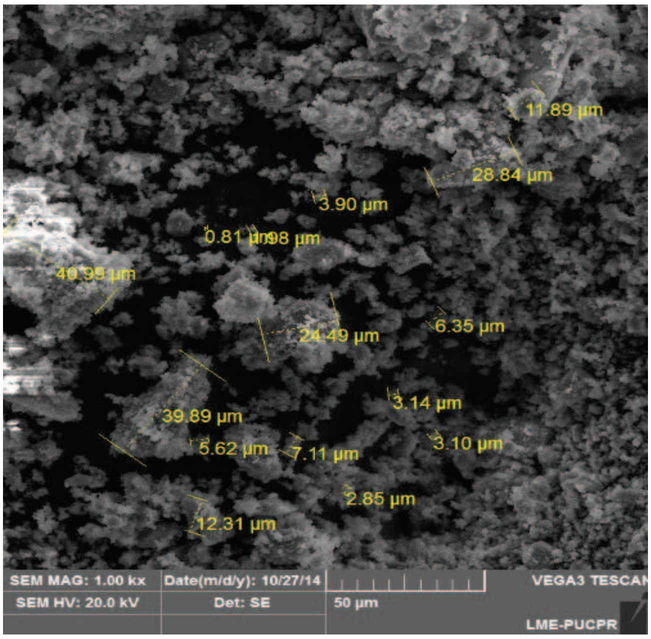


Fig. 5: Fotomicrografia obtida por MEV com aumento de 1000X e 20KV das partículas de biovidro utilizadas neste estudo.

Discussão

O esmalte dental, ao final do estágio de maturação, é composto por 90% de minerais e 3% de proteínas e lipídeos. O conteúdo de água no esmalte é suficiente para difundir ácidos e outros componentes através do espaço interprismático e desta forma propiciar a desmineralização [36].

Nos resultados de microdureza do presente trabalho foi demonstrado maiores valores após o ciclo erosão/remineralização para todas as soluções remineralizantes. Entretanto os demais testes não apresentaram um resultado satisfatório para o grupo Elmex®, isto pode ser justificado pela sua diferente composição das demais soluções testadas e também pela sua atuação sobre o esmalte dental. O Elmex®, é um produto comercializado especificamente para erosão dental e sua composição engloba NaF, AmF e o $SnCl_2$. O teste de dureza para este grupo obteve valores maiores que o G1 (água destilada) e semelhantes ao G7 (controle positivo), sugerindo uma possível proteção contra erosão dental e concordando com estudos anteriores [5,37]. Em um estudo [13] onde diferentes formas de fluoretos foram avaliadas, o TiF_4, SnF_2 e AmF foram os que demonstraram menor perda de esmalte, sendo este último mais eficaz a um pH em torno de 4,0, semelhante ao produto comercial utilizado no presente estudo.

A reação de produtos de SnF_2 com o esmalte não é completamente determinada, porém em um estudo [38] foi demonstrado que a reação deste com a hidroxiapatita resulta em precipitados como Sn_2OHPO_4, $Sn_3F_3PO_4$, $Ca(SnF_3)_2$ ou sais de CaF_2. Além do SnF_2, o $SnCl_2$ é capaz de depositar estanho sobre o esmalte [38], isto pode explicar a presença de Sn detectada pelo teste de EDS, assim como os picos menos intensos de hidroxiapatita identificados pelo DRX, e valores satisfatórios de dureza.

Os biovidros analisados apresentam alta quantidade de Ca e P e de acordo com um estudo recente [19], agentes remineralizantes contendo Ca e P apresentam alta penetração e maior potencial de remineralização do que substâncias com flúor. O grupo do biovidro 45S5 e dos biovidros experimentais mostraram maiores picos de hidroxiapatita e de fosfato na superfície após os 9 dias de ciclo em relação ao Elmex® e a água. O mecanismo de remineralização do esmalte pelo biovidro 45S5 foi demonstrado pela deposição de uma camada firmemente aderida ao esmalte e enriquecida por íons [18]. O pó de biovidro

45S5 libera em meio ácido o cálcio, o fosfato e o sódio. Estes íons penetram pelas porosidades da superfície do esmalte para áreas mais profundas de lesões descalcificadas, deixando esta subsuperfície de esmalte saturada com íons cálcio e fosfato [25] e, consequentemente, aumentam a dureza. Apesar da dureza entre os biovidros experimentais apresentarem-se semelhantes entre si, nas diferentes profundidades, os demais testes mostraram diferenças entre eles.

Nas imagens obtidas por MEV, os grupos biovidro 45S5, PCNSrTi e PCNSrMg apresentaram uma camada na superfície que sugere a deposição de substância. O grupo do biovidro experimental PCNSr não apresentou essa camada e mostrou a superfície do esmalte semelhante ao grupo 1. A adição do Mg e Ti ao PCNSr alterou a estrutura do vidro tornando-a mais rígida e diminuindo sua taxa de degradação, assim, como o Sr aumenta a solubilidade em vidros fosfatos [30], o grupo que apresenta apenas Sr na composição pode ter solubilizado rapidamente, não tendo tempo suficiente para reagir com a estrutura do esmalte e assim formar cristais de hidroxiapatita, isto pode ser confirmado com os resultados encontrados nos testes de Raman e DRX.

A adição de óxido de estrôncio aos vidros fosfatos tem papel importante na formação óssea e redução de reabsorção, aumentando assim sua bioatividade [30], porém o efeito do estrôncio no esmalte dental ainda não é documentado. Em um estudo sobre o efeito de dentifrícios na erosão dental foi detectado o efeito preventivo do cloreto de estrôncio sobre o esmalte, entretanto isto não foi verificado em todas as formulações [39]. De acordo com alguns autores [40,41] o estrôncio pode substituir o cálcio na hidroxiapatita formando $(SrCa)_{10}(PO_4)_6(OH)_2$ todavia, estudos mais específicos são necessários para verificar estas suposições.

A incorporação de 5% TiO_2 a vidros fosfatos tem excelente papel na formação de osso, biocompatibilidade [34] e redução da taxa de degradação [30,34]. Fluoretos altamente concentrados associados ao titânio podem ser efetivos na inibição da erosão [13]. Entretanto, como constituinte do biovidro e na ausência de flúor ainda não existem artigos publicados. A presença de uma camada depositada sobre a superfície do esmalte no grupo 5 pode ser explicada pela menor taxa de degradação deste material [30]. Isto também pode justificar a menor formação de hidroxiapatita e fosfato, quando comparado ao biovidro PCNSrMg, uma vez que degradando mais lentamente este material irá liberar Ca e PO_4 aos poucos ou em menor quantidade. Entretanto a permanência de uma camada sobre a estrutura de esmalte pode também ser uma barreira mecânica contra a ação de ácidos [42], o que pode contribuir para uma redução da desmineralização, este fato vai de encontro aos resultados de microdureza, onde este grupo foi semelhante aos demais biovidros.

A presença do Mg em fosfatos de cálcio tem recebido muita atenção devido a sua influência indireta no metabolismo mineral promovendo reações catalíticas e controlando funções biológicas [33]. Em um estudo para avaliar a remineralização da dentina com biovidros foi verificado que um biovidro modificado por Mg foi capaz de formar hidroxiapatita na dentina desmineralizada [26]. Apesar da composição do biovidro utilizado diferir do que foi analisado neste estudo e de não haver relatos na literatura sobre o efeito de biovidros com adição de Mg no esmalte dental, o grupo PCNSrMg apresentou resultados satisfatórios em todos os testes empregados neste estudo.

Apesar da sílica ter um papel importante na formação de osso e calcificação [33] a resposta celular humana ainda não é totalmente esclarecida e há estudos que indicam que nanopartículas de sílica podem causar dano tecidual, citotoxidade, disfunção endotelial e progressão de neurodegeneração [29]. Desta forma, a confecção de biovidros a base de fosfato de Ca e Sr e com a solubilidade controlada pela adição de óxidos de Ti e Mg torna-se interessante por não apresentar sílica na sua composição e ainda apresentar um efeito benéfico frente à erosão dental.

A saliva presente no meio oral atua como fator de proteção neutralizando e tamponando os ácidos responsáveis pela desmineralização do esmalte [10]. A película adquirida, que também é proveniente da saliva, é composta por glicoproteínas, proteínas, lipídeos e enzimas [43] que agem como uma membrana semi-permeável impedindo o contato entre os ácidos e a estrutura dentária [44]. O biovidro 45S5 pode reagir com os íons presentes na saliva, potencializando a remineralização dental [10]. Desta forma, estudos futuros devem ser realizados para avaliar os efeitos dos biovidros experimentais na presença de saliva.

A remineralização dental é facilitada com a utilização de pequenas partículas de biovidros [7]. No presente estudo, as partículas utilizadas apresentaram um tamanho médio de 14 µm, um tamanho menor do que o comumente utilizado em pesquisas anteriores cujas partículas variaram de 30 µm a 710 µm [7,26], o que pode ter contribuído para o mecanismo de ação desses materiais experimentais e assim incentiva próximas pesquisas com diferentes substratos e também maiores concentrações de biovidro.

Conclusão

Com base nos dados obtidos todas as substâncias remineralizantes podem melhorar a microdureza do esmalte erodido, entretanto maior formação de hidroxiapatita foi encontrada pelos biovidros. Dentre os biovidros experimentais estudados os biovidros compostos por PCNSrMg e PCNSrTi apresentaram potencial remineralizante consistente em todos os testes utilizados.

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ARTICLE IN ENGLISH

Title Page

Title: Effects of bioglass on the remineralization of enamel subjected to dental erosion

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Abstract

Objective: evaluate the effects of experimental bioglass on the remineralization process of dental enamel subjected to acid erosion *in vitro*. Materials and methods: Thirty-five third molars were cut with a metallographic diamond disk to obtain 3mm × 3mm enamel fragments that were then embedded in acrylic resin and polished. The specimens were randomized into seven experimental groups: G1- water; G2- Elmex®; G3- 45S5 Bioglass; G4- experimental PCNSr Bioglass; G5- experimental PCNSrTi Bioglass; G6- experimental PCNSrMg Bioglass; and G7- without treatment. The specimens were subjected to erosion/remineralization cycles involving the application of 0.3% citric acid for 2 min, washing in deionized water for 1 min, and the application of a remineralizing substance for 3 min, twice a day, for 9 days. After this, the specimens were subjected to the following assessments: scanning electron microscopy (SEM), X-ray dispersive spectroscopy, X-ray diffraction (XRD), Raman spectroscopy, and Knoop microhardness measurements at depths of 20 µm,45 µm,70 µm, and 100 µm. Results: All of the remineralizing substances exhibited greater microhardness than G1 ($p< 0.05$), and these values were statistically similar to G7. In the XRD and Raman spectroscopy assessments, the groups with the highest hydroxyapatite and phosphate intensity peaks were, in descending order, G3, G6, G5,G4, G2,and G1. SEM images indicated conditioning enamel patterns in G1 and G4, in contrast to the other groups. Significance: Among the different experimental bioglasses assessed, PCNSrMg and PCNSrTi bioglass showed consistent remineralizing potential across all of the assessments performed.

Keywords: bioglass, dental erosion, remineralization, hardness, enamel

Introduction

Dental erosion involves alterations to the dental structure, because mineral loss leads to changes in the mechanical and physical properties of the tooth [1,2]. Enamel erosion is initially expressed as a partial demineralization of the surface, resulting in the softening of the tooth [3,4]. If erosion persists, dissolution of consecutive layers of hydroxyapatite crystals leads to permanent loss of volume and, in more advanced stages, dentin exposure [1].

As dental erosion is the result of exposure to extrinsic or intrinsic acids, it is preferable to reduce or avoid contact with acids to prevent or contain the erosive process. However, it is impossible to completely avoid acid contact throughout an individual's life [1,5,6]. Therefore, an early diagnosis, in addition to the development of substances that reduce demineralization or promote remineralization [7–10], is required to treat dental erosion, which is considered a risk factor of oral health [11]. There is a high prevalence of dental erosion in the permanent teeth of children and adolescents; it has been reported to vary from 25.1% in Brazil, 39.8% in the US, 50.0% in the UK, to 51.6% in Greece [12]. The high prevalence in the majority of countries has been related to an acidic diet, i.e., erosion of extrinsic origin.

Strategies for avoiding or reducing the erosive process include the use of substances such as fluoride [11,13–15] and other agents that facilitate remineralization [8,15,16]. Stannous fluoride provides protection against demineralization and consequently reduces mineral loss [13,14,17]. Currently, bioactive substances are utilized in dentistry to induce remineralization; these include casein phosphopeptide-amorphous calcium phosphate (CCP-ACP) [9,16], 45S5 Bioactive glass (Novamin®) [8,18,19], and calcium and phosphate silicate [4,6]. These bioactive substances have the ability to deliver calcium and phosphate to the eroded surface, consequently reducing mineral loss and promoting remineralization [8,19]. CPP-ACP is utilized in several commercially available dental products such as toothpaste [9,16], dental bleach [20,21], and restorative materials [22].

Novamin® is composed of bioglass 45S5 and was the first bioactive substance to be developed. It has been successfully utilized in a variety of clinical applications, including dentistry [7,19,23–25]. It is present in several types of dental materials such as toothpaste [19], materials for prophylaxis [26], dental bleaching [27], and composite resins [28]. However, there is still no consensus in the literature regarding the cumulative effect of silica in the body [29]. Therefore, the development of new bioactive materials without the presence of silica is an area of research interest in dentistry. A calcium and strontium phosphate-based bioglass without silica, modified by the presence of magnesium or titanium, has been recently developed [30].

Strontium has been utilized in dentistry since 1950, mainly for the treatment of dentin hypersensitivity [31]. This element strongly adsorbs to calcifying tissues such as enamel and dentin [31,32] and can be added to phosphate glass; however, this increases its rate of degradation [33]. To reduce this problem, the addition of titanium oxide and magnesium has been shown to reduce solubility without compromising bioactivity [30,34]. Therefore, there is a need to assess the dental effectiveness of calcium- and strontium phosphate-based bioglass, with solubility controlled by the addition of titanium or magnesium oxide.

The aim of this *in vitro* study was to evaluate the effects of experimental bioglass on the remineralization process of dental enamel subjected to acid challenge. Chemical and morphological changes on the enamel surface were evaluated qualitatively by X-ray diffraction (XRD), Raman spectroscopy, scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS). The null hypothesis to be tested was that there would be no difference in enamel mineral loss between the different remineralizing agents.

Material and methods

Preparation of specimens

In total, 35 extracted human third molars were utilized after obtaining approval from the Ethics Committee in Research. The teeth were cut using a metallographic cutter with a diamond disk (Struers A/S, Ballerup, Denmark) under continuous irrigation to obtain 3mm × 3mm × 2mm enamel buccal surface fragments. The specimens were embedded in acrylic resin, polished with silicon carbide abrasive papers #800, #1000, and #1200 (3M Brazil, Sumaré, SP, Brazil), and then with cerium oxide in a polisher (Buehler Ltd., Lake Bluff, IL, USA). After polishing, specimens were observed under an optical microscope with a 50× magnification (Olympus, Sao Paulo, SP, Brazil) to check for the presence of enamel and to allow specimen standardization. The 35 buccal teeth specimens were randomized into seven groups (n= 5) for the application of different test substances and subsequent erosive challenge (Table 1).

Groups	Remineralising solution	Composition
G1	Deionized water (negative control)	---
G2	Stannous chloride, amine fluoride, sodium fluoride (Elmex®)	800 ppm Sn^{2+} as $SnCl_2$, 125 ppm F^- as amine fluoride, 350 ppm F^- as NaF.
G3	Bioglass 45S5	45%SiO_2, 24,5%Na_2O e CaO e 6% P_2O_5
G4	Experimental Bioglass PCNSr	40%P_2O_5, 30%CaO, 25% Na_2O, 5%SrO
G5	Experimental Bioglass PCNSrTi	40%P_2O_5, 30% CaO, 20% Na_2O, 5% SrO, 5% TiO_2
G6	Experimental Bioglass PCNSrMg	40%P_2O_5, 30% CaO, 20% Na_2O, 5% SrO, 5% MgO
G7	Positive control (no treatment)	--

Table 1: Specification of groups according to the remineralising solution used and composition

Erosive challenge

A 0.3% solution of citric acid with a pH of 3.2, adjusted using sodium hydroxide, was used for the erosive challenge. Each specimen received a1mL application of this solution during a 2-min stirring period; 1mL was added each minute. Two applications were administered per day for a total period of 9 days. Following the erosive challenge, the specimens were washed with 5 mL of deionized water in an ultrasonic bath for 1 min.

Application of remineralizing solutions

Remineralizing solutions were administered according to Table 1. Each specimen received 1 mL of bioglass comprising 1 g of bioglass in 5 mL of deionized water that had been place in an oven at 37℃ for 3 min. Between erosion/remineralization cycles, the specimens were stored in relative humidity at 37℃. The G7 control group underwent neither erosive challenge nor application of a remineralizing substance.

Preparation of bioglass

Experimental bioglass was prepared according to the methodology described by Weiss et al. [30] and the commercial 45S5 bioglass, used as reference material, was prepared according to the manufacturer's instructions. Milling was performed in a high energy ball mill (Mixermill5100–SPEX®SamplePrep, Metuchen, NJ, USA). Ten grams of bioglass were milled, one at a time, for 8 h and at a speed of 455 rpm.

X-ray diffraction

Three specimens from each group were analyzed using X-ray diffraction (DRX7000, ShimadzuCorp.,Tokyo,Japan) 9 days after the products had been applied. The diffraction intensity in each specimen was measured by scanning with a grazing angle (10˚) in the range 20°–80°, CuK α radiation, and at speed of 1° per minute. After obtaining the graphs, the base line of spectra in the four largest intensity peaks were obtained and mathematical adjustments were made using a Gaussian curve with the FITYK software, followed by calculation of the area. The sum of the area of the most intense peaks corresponding to hydroxyapatite was calculated, qualitatively indicating the crystalline fraction of hydroxyapatite on the surface.

Scanning electron microscopy and energy-dispersive X-ray spectroscopy

Representative samples of each group were used for the enamel mineral content analysis involving an X-ray detector coupled to a SEM. The main elements analyzed by EDS were calcium and phosphorus. The enamel surface was observed by SEM following the erosion/remineralization cycles. The specimens were coated with gold and examined under 1000× amplification. The analysis of the mean bioglass particle size was performed by SEM.

Raman spectroscopy

The Raman spectroscopy measurements were performed on two specimens per group in a WITEC alpha 300 model (WITecInstrumentsCorp., Knoxville, TN). A 13.8 mW red laser (He-Ne), with a wavelength of 632.8 nm and spectrum resolution of 0.02 cm^{-1}, was utilized for excitation. The spectra analyzed comprised phosphate bands (wavelength 960 cm^{-1}) and data was analyzed with WITec Project 2.08 software. The base line of spectra was zeroed and peak height evaluated.

Knoop microhardness

Prior to the hardness analysis, specimens were sectioned at their center with a diamond disk in a metallographic cutter (Struers A/S, Ballerup, Denmark), under continuous irrigation. The specimens were then worn with silicon carbide abrasive paper (#1200 - 3M Brazil, Sumaré, SP, Brazil) and polished with a felt disc and cerium oxide in a polisher (BuehlerLtda, Lake Bluff, IL, USA).The evaluation of enamel Knoop microhardness was performed using a Shimadzu Micro Hardness Tester (HMV-2T, ShimadzuCorp., Tokyo, Japan) with a static load of 10 g for 10 s [38]. Six indentations spaced 25-μm apart were performed at depths of 20 μm, 45 μm, 70 μm, and 100 μm from the external surface; the mean indentation for each depth was then calculated [35].

Statistical Analysis

The data were subjected to statistical analysis; after checking for normality and homogeneity using the Shapiro-Wilk test and Levene's test, respectively, a two-tailed analysis of variance was performed with multiple comparisons by Tukey HSD. Statistical significance was accepted at $p<0.05$.

Results

After all treatments, the XRD pattern observed was similar to hydroxyapatite (default standard JCPDS 009-0432) and the sum of the highest intensity peaks qualitatively indicated the presence of crystals on the enamel surface. The groups displaying the highest hydroxyapatite intensity peak were as follows, in descending order: Bioglass 45S5, PCNSrMg, PCNSrTi, PCNSr, Elmex, and water.

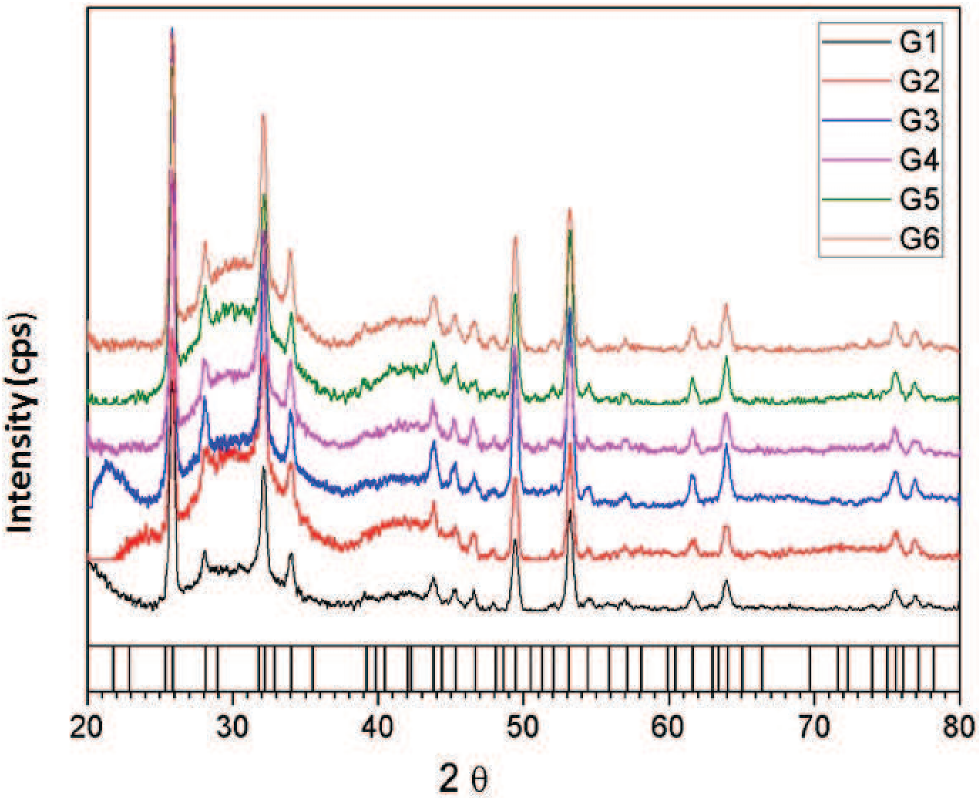
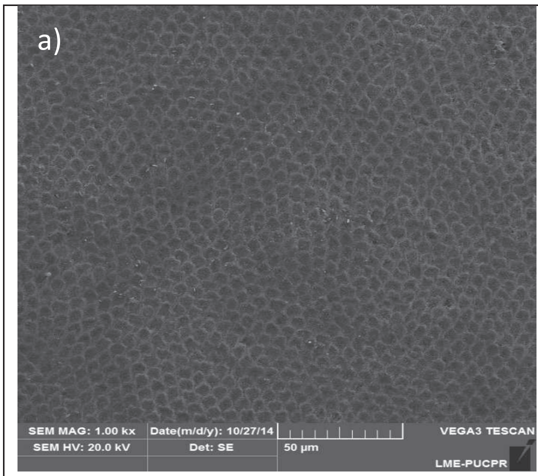
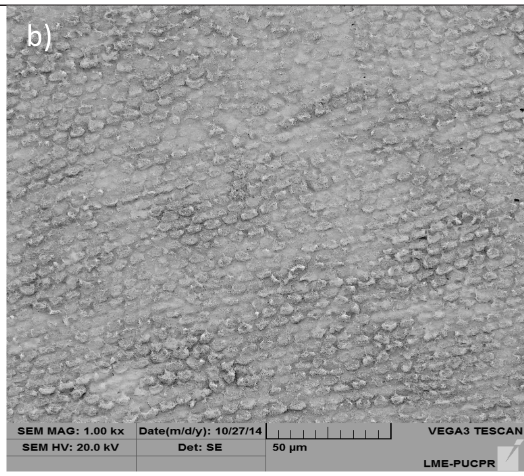


Fig. 1: XRD analysis of enamel surface after treatments.

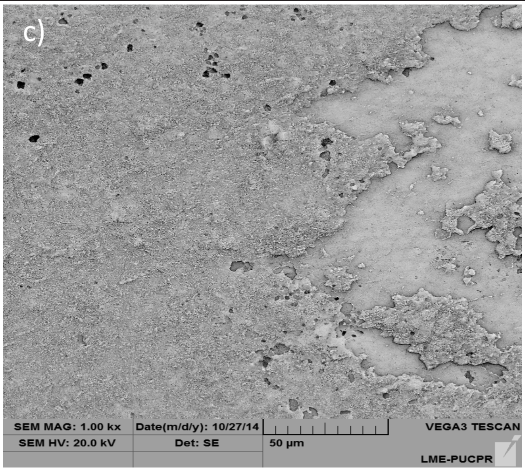
The images obtained by SEM and the EDS data are presented in Figure 2.



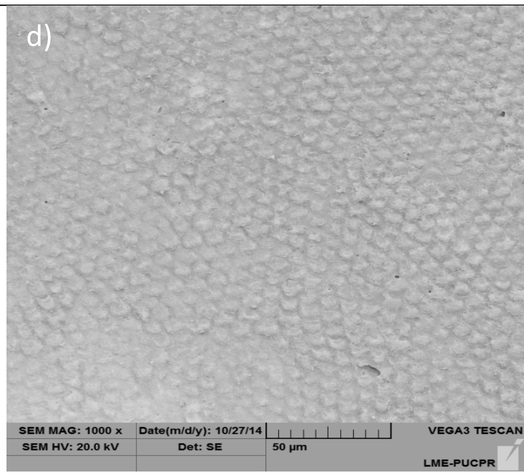
	Wt%
O	54.2
Ca	28.2
P	16.9
Na	0.7



	Wt%
O	42.2
Ca	34.7
P	15.8
Sn	5.8
Cl	0.7
Na	0.6
Si	0.3



	Wt%
O	46.0
Ca	33.3
P	16.0
Si	4.1
Na	0.6



	Wt%
O	41.3
Ca	38.7
P	19.1
Na	0.6
Sr	0.3

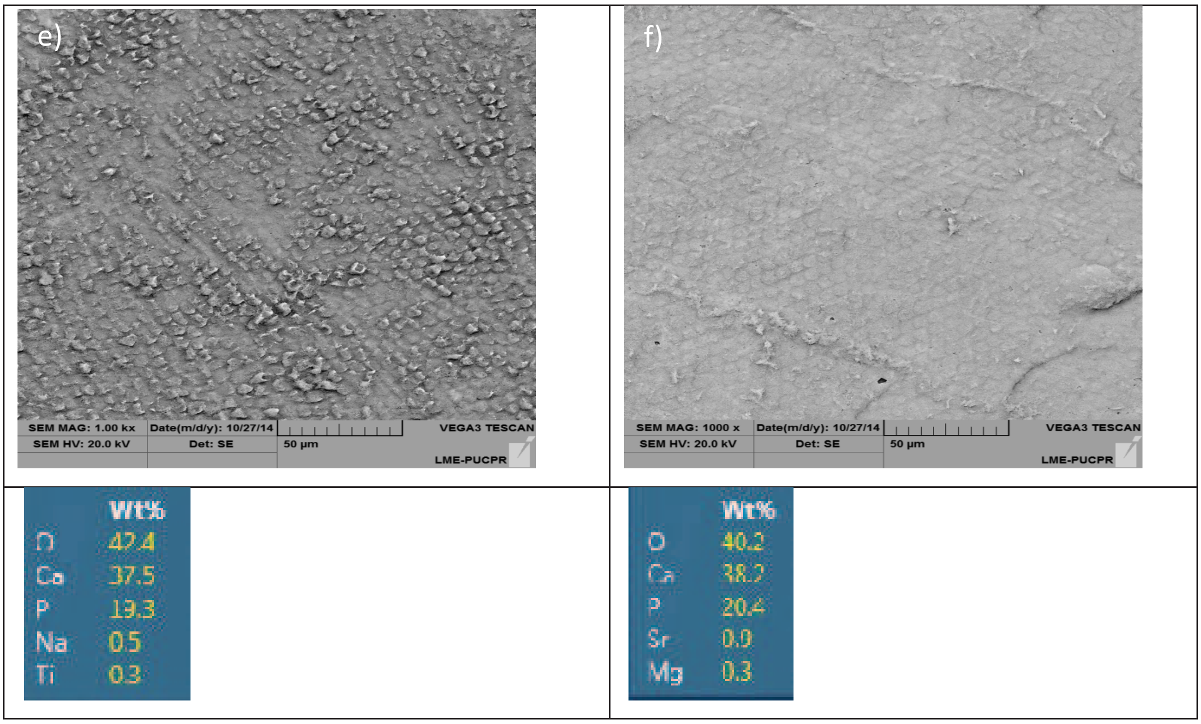


Fig. 2: SEM images with increased 1000X and 20KV and EDS spectra of the enamel surface after the last cycle erosion/remineralization. a) Group 1 – negative control; b) Elmex®; c) Group 3- bioglass 45S5; Group 4- experimental bioglass PCNSr; Group 5- experimental bioglass PCNSrTi; Group 6- experimental bioglass PCNSrMg.

EDS revealed that the weight of all groups comprised between 28% and 38% of calcium and between 15% and 21% of phosphorus. Following erosion/remineralization cycles, SEM images revealed deposition of substances on the enamel surface in G2, G3, G5, and G6 (Fig. 1: b, c, e, f), with the greatest amount recorded in the latter three groups. However, G1 and G4 images revealed a similar pattern and an etched enamel appearance.

In the Raman spectroscopy, the groups with the highest intensity phosphate peaks (960 cm^{-1}) were those containing bioglass in the following order (similar to the XRD results): G3, G6, G5, G4, G2, and G1.

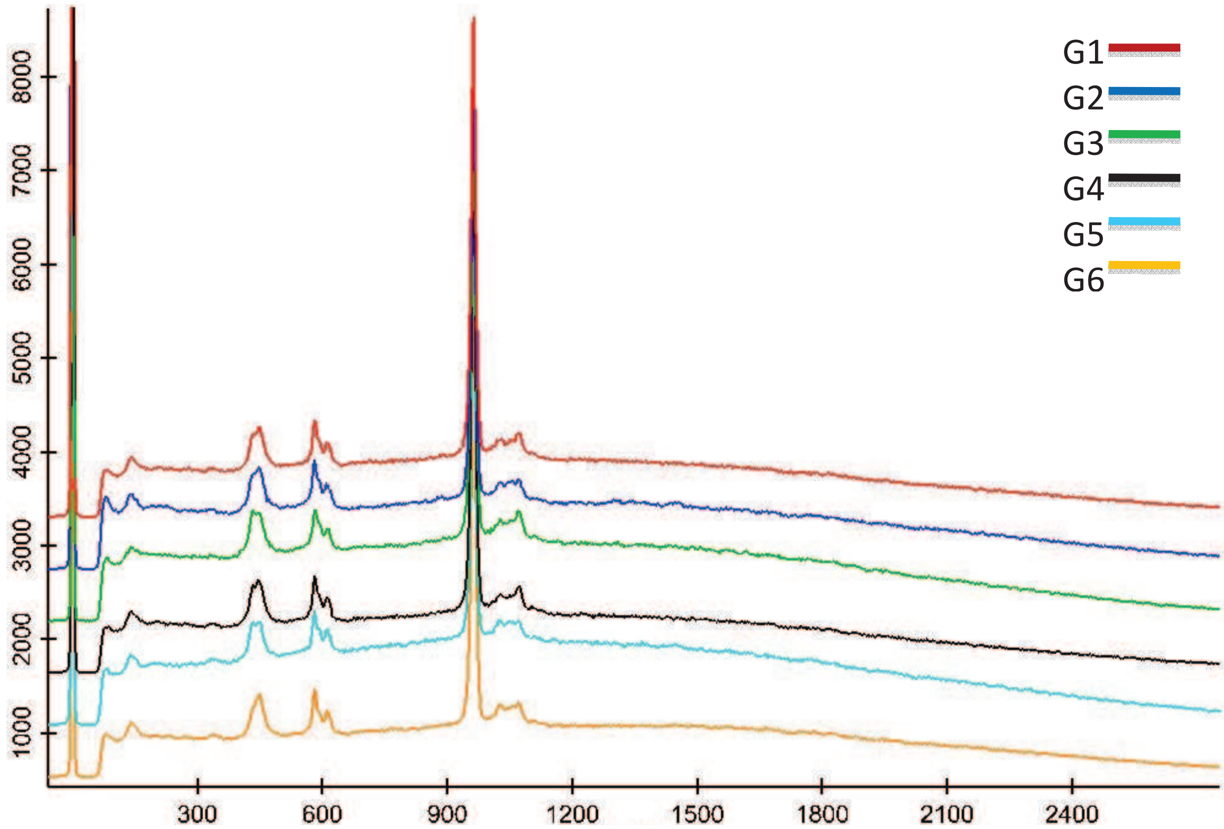


Fig 3: Representative spectrum of Raman obtained after the last cycle erosion/remineralization showing the characteristic band 960 cm^{-1} associated with phosphate band.

There was no significant difference in Knoop microhardness between treatments ($p< 0.05$) or according to depth ($p=0.4821$). However, there was a significant interaction between treatment and depth ($p< 0.05$). The results of the statistical comparisons are shown in Table 2 and Figure 4.

Table 2: Mean enamel Knoop microhardness values and standard deviations for each material evaluated, at different depths.

	GROUP 1 Water	GROUP 2 **Elmex®**	GROUP 3 45S5 Bioglass	GROUP 4 PCNSr Bioglass	GROUP 5 PCNSrTi Bioglass	GROUP 6 PCNSrMg Bioglass	GROUP 7 Positive Control
20 µm	139.48(12.86)^{a}	234.91(9.60)^{b}	238.34(18.81)^{b}	230.86(13.11)^{b}	223.10(5.66)^{b}	226.40(17.48)^{b}	256.16(20.50)^{b}
45 µm	146.36(16.87)^{a}	239.31(5.50)^{b,d}	235.48(17.50)^{b,d}	237.14(13.24)^{b,d}	223.34(15.09)^{b,d}	219.66(6.37)^{b,c}	259.08(23.74)^{d}
70 µm	144.67(13.02)^{a}	245.27(7.10)^{b}	240.76(13.70)^{b}	230.04(13.53)^{b}	226.76(12.93)^{b}	237.56(15.97)^{b}	260.90(15.40)^{b}
100 µm	156.27(18.48)^{a}	255.06(7.77)^{b}	245.65(15.13)^{b}	235.50(17.18)^{b}	234.64(23.58)^{b}	247.64(17.56)^{b}	264.64(21.44)^{b}

*Letras diferentes indicam diferença estatística entre colunas (p<0,05) de acordo com o teste Tukey HSD.

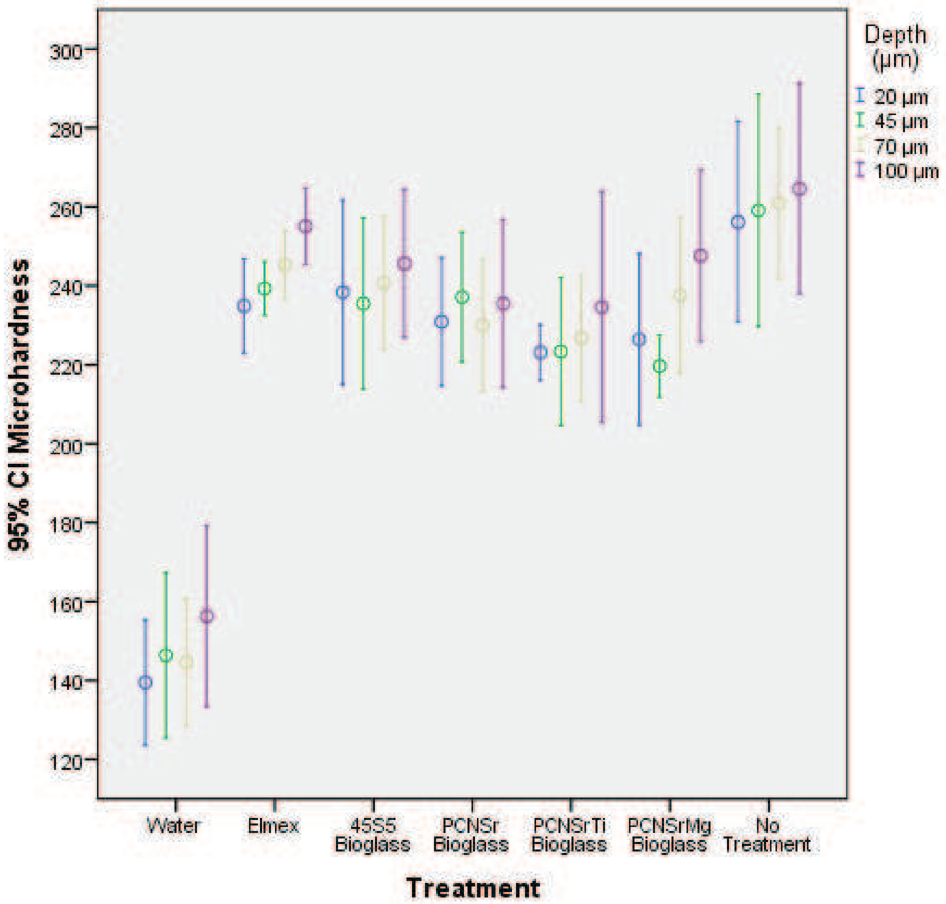


Fig. 4: Box plot showing the distribution of microhardness according with diferents treatments and depths.

The lowest microhardness values were recorded in the group which did not receive application of a remineralizing substance (G1) and was significantly different from the values of the other groups ($p < 0.05$). All of the groups that utilized remineralizing substances were statistically similar to the group not subjected to acid challenge (G7), independent of depth ($p > 0.05$), with the exception of the PCNSrMg group at a depth of 45µm ($p = 0.02$). SEM analysis revealed that the mean size of the bioglass particles utilized was 14µm (Fig. 5).

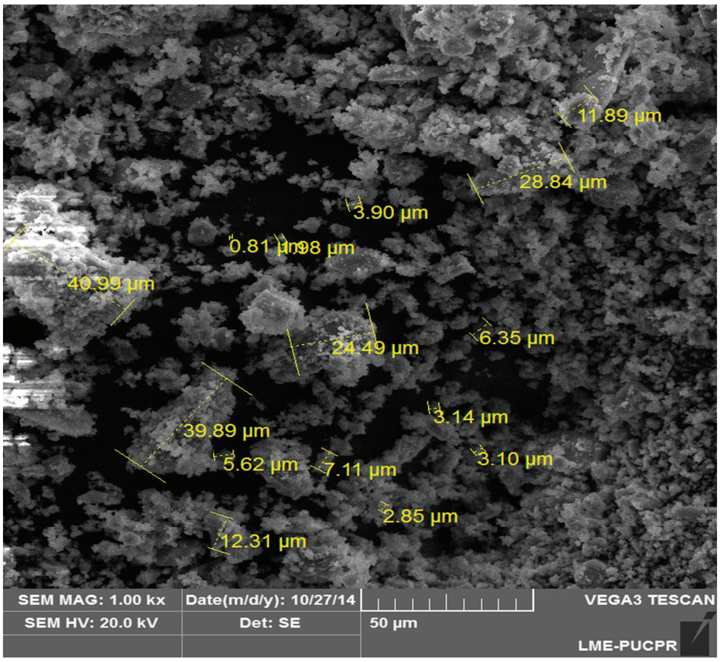


Fig. 5: Scanning electron micrograph of bioglass particles used in this study with 1000X and 20KV.

Discussion

Dental enamel, at the end of the maturation stage, comprises 90% minerals and 3% proteins and lipids. Enamel water content is sufficient to allow the diffusion of acids and other components through the interprismatic space and therefore facilitates demineralization [36].

In this study, the microhardness values were greater after the erosion/remineralization cycles for all the remineralizing solutions tested. However, the remaining tests did not produce satisfactory results for the Elmex® group; this can be explained by its different composition from the other solutions tested and by its effects on the enamel. Elmex® is marketed specifically for dental erosion and its composition includes sodium fluoride, amine fluoride, and tin chloride. Its hardness values were greater than G1 (distilled water) and similar to G7 (positive control) suggesting potential protection against dental erosion, in agreement with previous studies [5,37]. In a previous evaluation of different forms of fluoride [13], titanium fluoride, tin fluoride, and amine fluoride reduced the loss of enamel, with the latter being more effective at a pH of approximately 4.0, similar to the commercial product utilized in the present study.

The reaction of tin fluoride-containing products with enamel is not completely understood; however, one study [38] demonstrated that the reaction with hydroxyapatite results in precipitates such as Sn_2OHPO_4, $Sn_3F_3PO_4$, $Ca(SnF_3)_2$, and CaF_2 salts. In addition to tin fluoride, tin chloride is able to deposittin on the enamel [38]; this may explain the presence of tin detected by EDS in the present study, as well as the low intensity hydroxyapatite peaks identified by XRD and the satisfactory levels of hardness.

The bioglasses analyzed contained a high amount of calcium and phosphate, and according to a recent study [19], remineralizing agents containing these elements have a higher penetration and greater remineralization potential than fluorine-containing substances. The groups treated with 45S5 bioglass and experimental bioglass demonstrated higher hydroxyapatite and phosphate intensity peaks on the enamel surface after 9 days of cycles, compared with Elmex® and water. The mechanism of enamel remineralization by bioglass 45S5 was confirmed by the deposition of a layer firmly adhered to the enamel and by ion enrichment [18]. Bioglass 45S5 dust releases calcium, phosphate, and sodium into the acid medium. These ions deeply penetrate the pores of the enamel surface in decalcified lesions resulting in enamel subsurface calcium and phosphate ion saturation [25], consequently increasing the hardness. Although the hardness values were similar between the different types of experimental bioglasses at different depths, other tests revealed differences between the materials.

The SEM images revealed the presence of a surface layer indicating substance deposition in the 45S5, PCNSrTi, and PCNSrMg bioglass groups. The PCNSr experimental bioglass group did not present this layer and showed a similar enamel surface to G1. The addition of magnesium and titanium to PCNSr altered the glass structure, increasing its rigidity and reducing its degradation rate. Therefore, as strontium increases the solubility of phosphate glass [30], substances composed of this element may be solubilized quickly, without sufficient time for the reaction with the enamel structure to form hydroxyapatite crystals. This was confirmed by the findings from the Raman and XRD assessments.

The addition of strontium oxide to phosphate glass plays an important role in bone formation and reduction of resorption, and consequently increases its bioactivity [30]. However, the effect of strontium on dental enamel has not been reported. In a study investigating the effect of toothpastes on dental erosion, a preventive effect of strontium chloride on enamel was detected [39]; however, this has not been verified for all formulations. According to previous reports [40,41], strontium may replace calcium in hydroxyapatite forming $(SrCa)_{10}(PO_4)_6(OH)_2$; however, more specific studies are required to verify these assumptions.

The incorporation of 5% titanium dioxide in phosphate glass improves bone formation and biocompatibility [34], and reduces the degradation rate [30,34]. Highly concentrated fluorides, along with titanium, can be effective in the inhibition of erosion [13]. However, there have been no reports of titanium as a bioglass constituent utilized in the absence of fluoride. The presence of a deposition layer on the enamel surface in G5 can be explained by the lower rate of degradation of this material [30]. This may also explain the reduced formation of hydroxyapatite and phosphate compared with PCNSrMg bioglass because the slower degradation of this material releases calcium and phosphate at a slower rate or at a reduced amount. However, the presence of a deposition layer on the enamel structure can also form a mechanical barrier against the action of acids [42] and therefore may contribute to a reduction in demineralization. This supports the microhardness findings, which revealed that this group was similar to the other bioglasses.

The presence of magnesium in calcium phosphates has received a considerable amount of attention owing to its indirect influence on mineral metabolism, thereby promoting catalytic reactions and controlling biological functions [33]. In an evaluation of the remineralization of dentin with bioglass, a bioglass modified with magnesium was shown to be capable of forming hydroxyapatite in demineralized dentin [26]. However, the composition of this bioglass differed from that analyzed in the present study and there is a lack of available literature concerning the effects of bioglass with added magnesium on dental enamel. In this present study, the PCNSrMg group presented satisfactory results across all assessments.

Although silica plays an important role in bone formation and calcification [33], the human cellular response is not yet fully understood and some studies have indicated that silica nanoparticles may cause tissue damage, cytotoxicity, endothelial dysfunction, and progression of neurodegeneration [29]. Therefore, the preparation of the calcium- and strontium phosphate-based bioglass, without silica, with controlled solubility through the addition of titanium and magnesium oxides, should be considered for its potential beneficial effect against dental erosion.

The saliva present in the oral environment acts as a protective substance; it neutralizes and buffers the acids responsible for enamel demineralization [10]. The deposited saliva film, composed of glycoproteins, proteins, lipids, and enzymes [43], acts as a semi-permeable membrane preventing contact between the acids and the dental structure [44]. The 45S5 bioglass can react with the ions present in the saliva, leading to potential dental remineralization[10]. Therefore, evaluations of the effects of experimental bioglass on the presence of saliva are required in the future.

Dental remineralization can be facilitated through the utilization of small bioglass particles [7]. The mean particle size in the present study was 14 µm, smaller than those frequently used in previous studies (30 µm–710 µm) [7,26]. This may have contributed to the mechanism of action of these experimental materials. Therefore, further investigations using different substrates and higher concentrations of bioglass are encouraged.

Conclusion

On the basis of these findings, all remineralizing substances investigated in this study improved the microhardness of eroded enamel; however, bioglass resulted in a greater formation of hydroxyapatite. Among the different types of experimental bioglass studied, bioglass composed of PCNSrMg and PCNSrTi exhibited consistent remineralizing potential across all assessments.

Acknowledgements

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ANEXOS

Parecer do Comitê de ética

Comitê de Ética em Pesquisa da PUCPR

PUCPR

ASSOCIAÇÃO PARANAENSE DE CULTURA - PUCPR

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: EFEITO DE BIOVIDROS NA REMINERALIZAÇÃO DO ESMALTE DENTAL SUBMETIDO À EROSÃO DENTAL

Pesquisador: Andrea Freire de Vasconcelos Eckelberg

Área Temática:

Versão: 2

CAAE: 21975413.5.0000.0020

Instituição Proponente: Pontifícia Universidade Católica do Parana - PUCPR

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 543.265

Data da Relatoria: 26/02/2014

Apresentação do Projeto:

A pesquisa será laboratorial, com análises quantitativas.

Serão utilizados 60 dentes humanos, terceiros molares extraídos do banco de dentes da Pontifícia Universidade Católica do Paraná, após aprovação do Comitê de Ética em Pesquisa. Para análise química serão utilizados 30 dentes, sendo 60 espécimes divididos em 6 grupos (n=10), para os demais testes, nanoindentação e espectroscopia Raman serão utilizados também 30 dentes (60 espécimes), divididos em espécimes obtidos da face vestibular para a nanoindentação (n=5/grupo) e lingual ou palatina para a espectroscopia (n=5/grupo). Os espécimes serão distribuídos em 6 grupos de acordo com a substância a ser aplicada posteriormente ao desafio erosivo.

Objetivo da Pesquisa:

O objetivo deste estudo in vitro é avaliar o efeito de biovidros experimentais no processo de remineralização do esmalte dental submetido ao desafio ácido.

Avaliação dos Riscos e Benefícios:

São adequados de acordo com a natureza da pesquisa.

Riscos:

Não há riscos uma vez que o estudo utilizará dentes extraídos.

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Benefícios:
Caso o resultado seja satisfatório poderão ser desenvolvidos produtos que contenham biovidro para prevenir e conter a erosão dental. Não só produtos odontológico como também para uso diário do paciente

Comentários e Considerações sobre a Pesquisa:
Pesquisa laboratorial com análise quantitativa.

Considerações sobre os Termos de apresentação obrigatória:
- Dispensa o TCLE. Os dentes serão fornecidos pelo Banco de Dentes da Universidade (PUCPR), uma vez que os dentes lá contido já foram doados pelos paciente e já tiveram o TCLE devidamente preenchidos não há a necessidade de fazer um novo TCLE.
- É apresentado o termo de responsabilidade do pesquisador.

Recomendações:
sem recomendações

Conclusões ou Pendências e Lista de Inadequações:
O presente protocolo atende a resolução 466/12 em suas questões éticas.

Situação do Parecer:
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APÊNDICE

Fotos ilustrativas – Materiais e Métodos

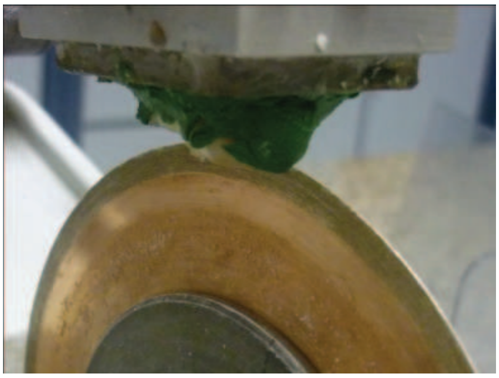

Fig A.1 -Corte dos dentes em cortadeira metalográfica com disco diamantado.

Fig A.2 - Espécime de esmalte 3X3mm incluídos em resina acrílica.

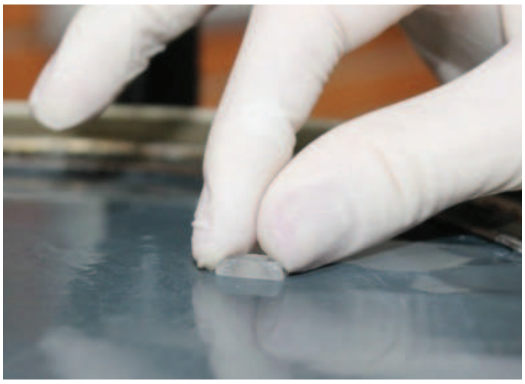

Fig A.3 - Padronização dos espécimes com lixa de carbeto de silício #800, #1000 e #1200.

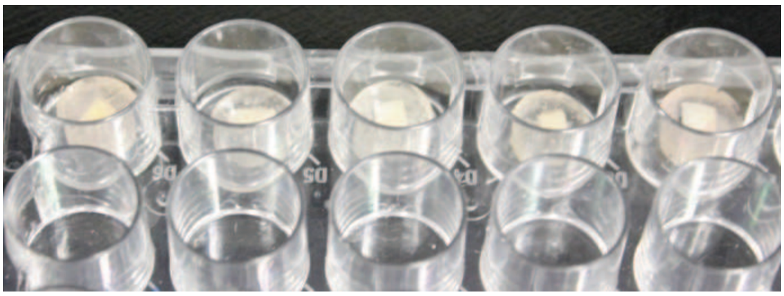

Fig A.4 - Dispositivo utilizado para aplicação das soluções remineralizantes.

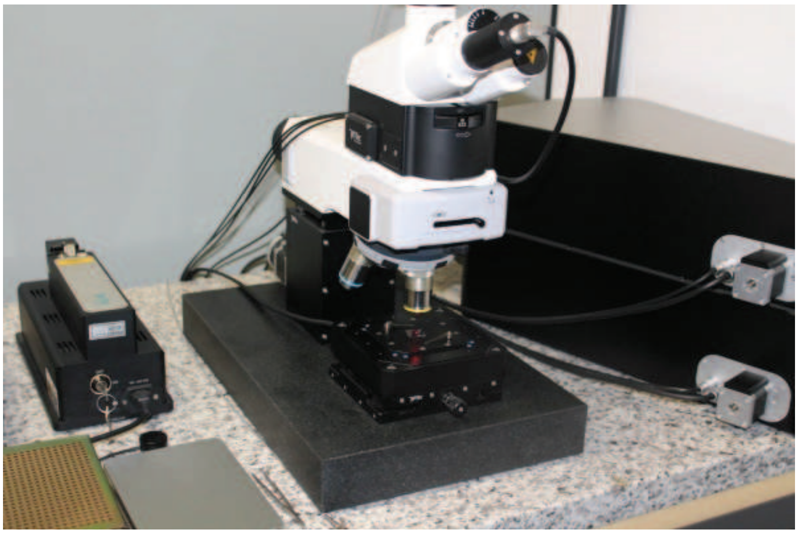

Fig A.5 - Aparelho Witec modelo Alpha 300 utilizado para espectroscopia de Raman.

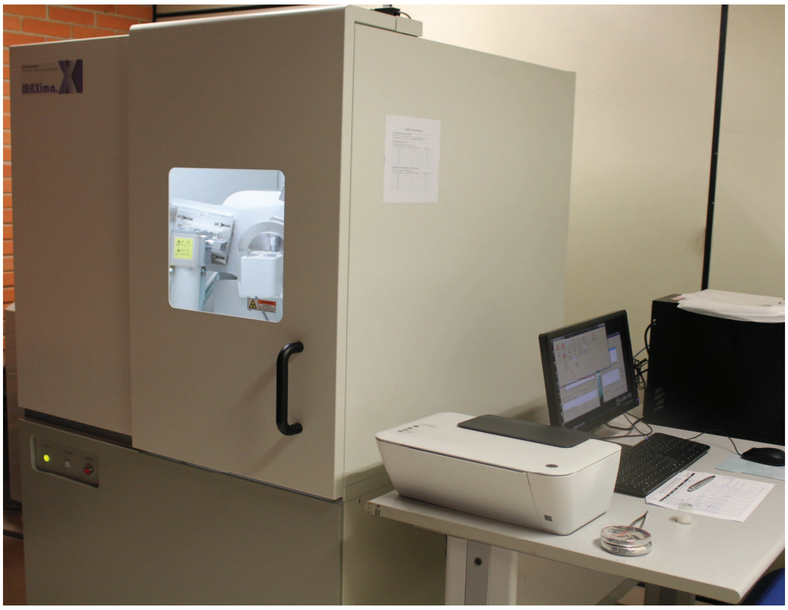

Fig A.6 -Aparelho DRX7000 Shimadzu utilizado para obtenção dos picos de hidroxiapatita.

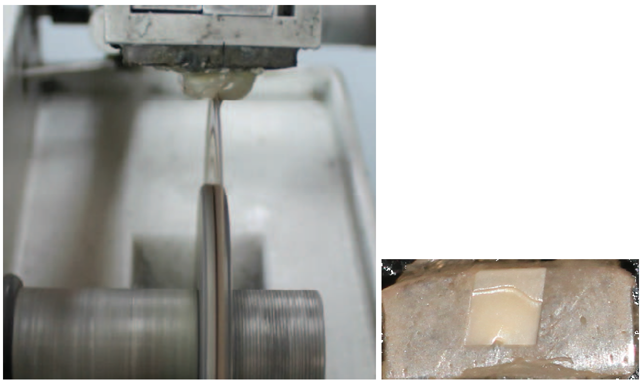

Fig A.7 - Corte das amostras para realização do teste de dureza Knoop em profundidade .

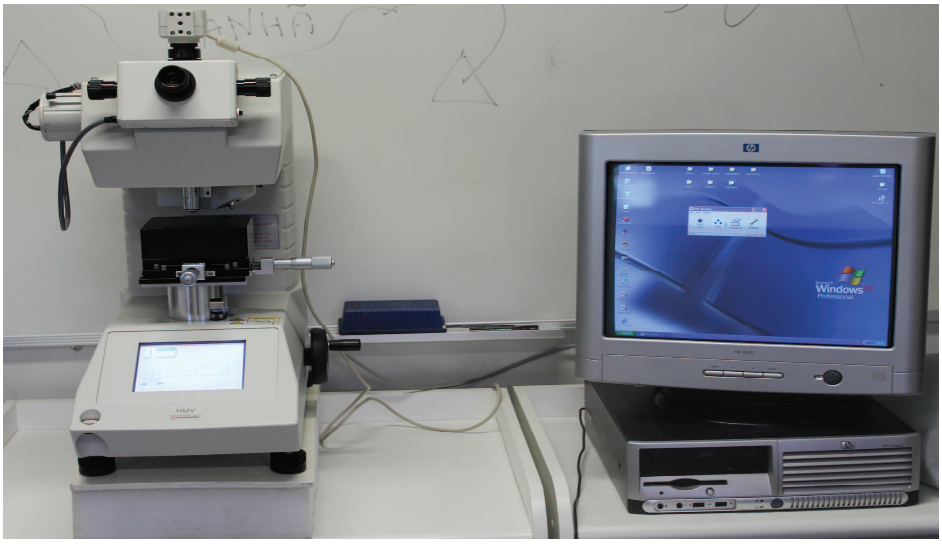

Fig A.8 - Microdurômetro HMV-2T, Shimadzu utilizado para obtenção dos dados de dureza.

Resumo dos artigos da discussão

Sierpinska T, Orywal K, Kuc J, Golebiewska M, Szmitkowski M. Enamel mineral content in patients with severe tooth wear. Int J Prosthodont. 2013 Sep-Oct;26(5):423-8

As quantidades de cálcio (Ca), magnésio (Mg), zinco (Zn), e cobre (Cu) em esmalte podem ser cruciais para manter a sua integridade e atenuar os potenciais efeitos ambientais nos dentes.

O cálcio e o magnésio são necessários para formação do esmalte e resistência dos tecidos duros. O esmalte é composto 90% minerais e 3% proteínas e lipídeos, o conteúdo de água presente no esmalte é suficiente para difundir ácidos pelo espaço interprismático e, assim, minerais como cálcio e fósforo são perdidos durante o processo de desmineralização.

O objetivo deste estudo foi verificar se a composição mineral do esmalte poderia influenciar o desgaste do dental.

Esse estudo utilizou 50 pacientes com erosão e 20 pacientes saudáveis e o desgaste dental foi avaliado de acordo com Smith e Knigh. Foram feitas biópsias para avaliar o conteúdo mineral e a espectroscopia de absorção atomica foi feita para avaliar Ca, Zn e Mg e Cu.

A quantidade de Ca e Mg dos pacientes com erosão é comparável com os pacientes saudáveis, dentes de pacientes com erosão são propriamente mineralizados. A influência de íons metálicos no esmalte é pouco conhecida. A concentração de Zn foi maior para os pacientes com erosão - o Zn pode interagir com HA pela absorção na superfície do cristal e/ou incorporação no cristal, baixa concentração de Zn pode inibir a remineralização. O Cu apresentou –se em menor concentração comparando com os pacientes saudáveis, e esta substância tem efeito inibitório na desmineralização pela estabilização do esmalte.

Ganss C, Lussi A, Grunau O, Klimek J, Schlueter N. Conventional and anti-erosion fluoride toothpastes: effect on enamel erosion and erosion-abrasion. Caries Res. 2011;45 (6):581-9.

Este estudo avaliou o efeito de produtos anti-erosão comparando com dentifrícios convencionais contendo NaF e Titânio. Foram utilizados dezoito grupos com várias substâncias e o ELMEX®como controle. O estudo consistiu em 2 experimentos de 10 dias; Experimento 1- erosão 6X de 2 minutos com 0,05% de ácido cítrico seguido por lavagem e aplicação da solução remineralizante por 2 minutos após a primeira e última erosão. O segundo experimento teve a adição da abrasão. A perda tecidual do esmalte foi avaliada por perfilometria e todos os produtos testados reduziram a perda mineral, entretanto substâncias com flúor possuem efeito limitado com a associação da abrasão. Os melhores efeitos foram encontrados com produtos contendo Sn.

Rakhmatullina E, Beyeler B, Lussi A. Inhibition of enamel erosion by stannous fluoride containing rinsing solutions. Schweiz Monatsschr Zahnmed. 2013;123(4):296-302.

Este estudo in vitro comparou o efeito de uma solução contendo Sn/F e uma fluoretada com a água. Os 90 espécimes de esmalte tiveram a formação de uma película salivar por 2 horas, aplicação de ácido cítrico 0,3% por 4 minutos sob agitação constante e em seguida foi realizada a aplicação de 10mL das respectivas soluções por 2 minutos. Estes procedimentos foram realizados 2 vezes ao dia por 4 dias. Foi realizado o teste de microdureza Knoop(antes e depois dos ciclos), espectroscopia de absorção atômica e MEV. Todos os métodos mostraram melhor efeito protetor de substâncias contendo Sn/F.

Ellingsen JE. Scanning electron microscope and electron micropobe study of reactions of stannous fluoride and stannous chloride with dental enamel. Scand J Dent Res 1985;94:299-305

O mecanismo de ação do fluoreto estanoso no esmalte não é bem documentado.Este estudo comparou o efeito do fluoreto estanoso com cloreto estanoso por microscopia eletrônica de varredura e espectroscopia de energia dispersiva de raios X. Os resultados mostraram que ambos os materiais depositam estanho sobre a superfície do esmalte e oEDS revelou alta concentração de estanho. O SnF_2 pode reagir com a hidroxiapatita e formar alguns precipitados como Sn_2OHPO_4, $Sn_3F_3PO_4$, $Ca(SnF_3)^2$ ou sais de CaF_2.

Bakry AS, Marghalani HY, Amin OA, Tagami J. The effect of a bioglass paste on enamel exposed to erosive challenge. J Dent. 2014 Jun 4.

O objetivo deste estudo foi avaliar o efeito da utilização do biovidro 45S5 e aplicação tópica de flúor. Foram obtidos fragmentos de esmalte de 3X2 mm da face vestibular de terceiros molares que foram lixadas e polidas. Os espécimes ficaram imersos em suco de laranja pH 3,85 por 1 hora e então foram divididos em 4 grupos: G1- aplicação de flúor por 5 min e lavagem, G2- aplicação de flúor por 24 h (sem lavagem) , G3- aplicação do biovidro 45S5 e proteção com uma camada de adesivo, G4- sem tratamento (controle). Todos os espécimes foram mantidos em saliva artificial por 24h após os tratamentos e então foram realizados os testes de MEV e EDS e as amostras foram seccionadas ao centro para realização da microdureza Knoop em profundidade. A microdureza foi avaliada em 30,40,50 e 100 µm com carga de 25g por 5s. O biovidro 45S5 aumentou a dureza da subsuperfície do esmalte erodido quando comparado aos grupos controle e F. Na profundidade de 100µm não houve erosão detectada. O pó do biovidro em meio acídico libera íons Ca, Na e P e simultaneamente mobiliza o Ca e P do esmalte subjacente que interagem com as partículas liberadas do biovidro e penetram nas regiões descalcificadas, saturando essa subsuperfície com Ca e P e formando também uma camada de sais na superfície.

Gjorgievska ES, Nicholson JW. A preliminary study of enamel remineralization by dentifrices based on Recalden (CPP-ACP) and Novamin (calcium-sodium-phosphosilicate). Acta Odontol Latinoam. 2010;23(3):234-9.

O objetivo deste estudo foi avaliar o potencial de remineralização de 2 dentifrícios, o Recaldent que possui CPP-ACP na sua composição e o Novamin que contem fosfossilicato de sódio e cálcio. Quinze espécimes de esmalte foram divididos em 3 grupos: G1- controle, G2- Recaldent e G3- Novamin.

Os espécimes de esmalte passaram por 3 ciclos de erosão por 24h com gel artifical de cárie (6% hidroxi-etil celulose, 0,1 mol/l de ácido lático e 1 mol/l de NaOH ajustados a um pH de 4,5) e aplicação dos dentifrícios por 15 minutos seguida de lavagem por 5 minutos. Os espécimes foram avaliados por MEV e EDS. No EDS foi observado maior quantidade de Si, P, Ca E Zn no grupo que utilizou Novamin, e o grupo que utilizou Recaldent teve aumento somente nos níveis de Ca e P. A MEV do grupo que utilizou o dentifrício Recaldent mostrou depósitos pequenos e amorfos, enquanto o Novamin mostrou depósitos largos. Os dois dentifrícios testados apresentam potencial para remineralizar o esmalte, especialmente o Novamin que forma uma camada firmemente aderida ao esmalte e enriquecida por íons.

Bakry AS, Takahashi H, Otsuki M, Tagami J. Evaluation of new treatment for incipient enamel demineralization using 45S5 bioglass. Dent Mater. 2014 Mar;30(3):314-20.

Este estudo utilizou 60 terceiros molares, obtendo fragmentos de 2x2 mm de esmalte. Os espécimes passaram por desmineralização durante 4 dias com ácido acético e então foram divididos em 4 grupos: G1- controle (sem biovidro e sem escovação), G2- biovidro sem escovação, G3- sem biovidro, apenas escovação, G4- biovidro + escovação. Após aplicação dos biovidros com ácido nos grupos 2 e 4, este material foi protegido com uma camada de adesivo e então todos os espécimes foram armazenados em saliva artificial por 24h. Após o armazenamento foram realizados 6000 ciclos de escovação e os espécimes passaram pelos testes de DRX, MEV da superfície e da interface e EDS da interface. A abrasão não afetou a porcentagem de cobertura do esmalte pela aplicação do biovidro, sugerindo que este material possui proteção contra lesão erosiva inicial pela formação de uma camada de HA resistente.

Weiss DSL,Torres RD, Buchner S, Blunk S, Soares P. Effect of Ti and Mg dopants on the mechanical properties, solubility, and bioactivity in vitro of a Sr-containing phosphate based glass. Journal of Non-Crystalline Solids.2014;386:34-38

Os vidros bioativos possuem capacidade de aderir ao osso e formar HA. Vidros com base de sílica tem demonstrado sucesso, entretanto a baixa taxa de degradação limita seu uso. Vidros com base de Ca e P são de grande interesse, possuem composição química similar a fase mineral do osso, degradam em meio aquoso e a solubilidade pode ser controlada alterando a composição.

Vidros baseados em fosfatos – a solubilidade é controlada pelas ligações entre P-O-P que são facilmente hidratadas, entretanto, esses vidros apresentam pobres propriedades mecânicas que podem limitar seu uso nas aplicações biomédicas. O óxido de estrôncio é importante para formação óssea, redução de reabsorção e aumenta a bioatividade, porém, aumenta a solubilidade em vidros fosfatados. A adição de óxidos de Ti e Mg aumenta as propriedades mecânicas e melhora a durabilidade química. Esse estudo comparou biovidros contendo Sr, SrMg e SrTi por meio de testes como: degradação, nanoindentação, tenacidade a fratura e bioatividade.

Os biovidros a base de fosfato de cálcio e estrôncio com Mg e Ti apresentaram maior dureza comparando ao biovidro que contém apenas Sr. A degradação dos biovidros experimentais foi, em ordem decrescente: Biovidro SrTi, Biovidro SrMg, Biovidro Sr.

Abou Neel EA, Chrzanowski W, Knowles JC. Effect of increasing titanium dioxide content on bulk and surface properties of phosphate-based glasses. ActaBiomater. 2008 May;4(3):523-34.

Após a confecção do biovidro a base de fosfato com adição de óxido de titânio (0-5-10-15%) foram realizados testes como DRX, liberação de íons, cultura celular, viabilidade celular, taxa de de degradação, análise térmica e de densidade.

A incorporação de 5-15% de óxido de titânio a vidros fosfatos aumenta a viabilidade celular, controla a taxa de degradação e libera íons benéficos.

Yu H, Attin T, Wiegand A, Buchalla W. Effects of various fluoride solutions on enamel erosion in vitro. Caries Res. 2010;44(4):390-401.

O objetivo deste estudo foi avaliar diferentes soluções de flúor na erosão do esmalte dental. As soluções avaliadas foram TiF_4,AmF, ZnF_2 ou SnF_2 com pH entre 1,2-7,8 ou 4. Todos espécimes tiveram aplicação das soluções remineralizantes por 3 minutos, ciclos erosivos com ácido cítrico pH 2,6 por 1 minuto, lavagem 30s com água e armazenamento em saliva artificial por 1h até o próximo ciclo. Foram realizados 6 desafios erosivos por dia com intervalo de 1 hora entre eles durante 5 dias. Efeitos da erosão foram avaliados por perfilometria, MEV, EDS e DRX após a aplicação das soluções remineralizantes e no final dos ciclos erosivos. O fluoreto de amina foi mais efetivo contra erosão comparando com os demais agentes fluoretados; A aplicação de TiF_4, SnF_2 e AmF resultou em menor perda de esmalte comparando com o grupo controle. O

Ca da HA pode ser substituído por titânio quando utilizado o TiF_4 e o AmF forma sais de fluoreto de Ca na superfície.

Bertoni E, Bigi A, Cojazzi G, Gandolfi M, Panzavolta S, Roveri N. Nanocrystals of magnesium and fluoride substituted hydroxyapatite. J InorgBiochem. 1998 Oct;72(1-2):29-35.

O desenvolvimento de novos materiais efetivos para reparar o sistema esquelético é uma meta da ciência de biomateriais. O magnésio é sem duvida um dos mais importantes íons bivalentes associados a apatitas biológicas, aumentando reações catalíticas. Nanocristais de hidroxiapatita foram sintetizados na presença de diferentes concentrações de íons magnésio e flúor em soluções – 1,5,10% peso e estes foram submetidos a caracterização química e estrutural.

Os dados do estudo indicaram que esta pesquisa experimental pode ser utilizada com sucesso para preparar nanoapatitas com cristalinidade, dimensões de cristal, composição e estabilidade muito próximas as apatitas biológicas.

Bose S, Tarafder S, Banerjee SS, Davies NM, Bandyopadhyay A. Understanding in vivo response and mechanical property variation in MgO, SrO and SiO_2 doped β-TCP. Bone. 2011 Jun 1;48(6):1282-90.

O objetivo deste estudo foi avaliar a influência de MgO, SrO e SiO_2 nas propriedades mecânicas e biológicas do β-TCP (beta tricálcio fosfato).

A presença de Sr em CaP promove funções osteoblásticas e consequentemente formação óssea. O Mg é sem duvida um dos mais importantes íons bivalentes associados a apatitas biológicas e sua substituição em CaPs tem recebido muita atenção devido ao seu papel nas mudanças qualitativas da matriz óssea, e influencia indireta no metabolismo mineral, promovendo reações catalíticas e controlando funções biológicas.

A sílica é um elemento importante que auxilia na formação óssea e calcificação, estimula atividades celulares como proliferação e diferenciação de células como osteoblastos. Neste estudo verificou-se que a adição de MgO/SrO reduz o tempo de formação óssea, melhora as propriedades mecânicas e diminui a taxa de degradação tendo potencial para reparos ósseas.

Wang Z, Jiang T, Sauro S, Wang Y, Thompson I, Watson TF, Sa Y, Xing W, Shen Y, Haapasalo M. Dentine remineralization induced by two bioactive glasses developed for air abrasion purposes. J Dent. 2011

O objetivo do presente estudo foi avaliar a remineralização dentinária induzida pelo biovidro 45S5 e um biovidro modificado após um periodo de 7 dias de armazenamento em saliva artificial. Foram utilizados 45 discos de dentina divididos em 3 grupos: G1-saliva , G2- biovidro 45S5, G3- biovidro modificado (M-BAG). O tamanho médio das partículas dos biovidros utilizados foi entre 30-90 µm. Os discos foram cortados em 2 metades onde uma foi parcialmente desmineralizada com 0,5M de EDTA por 5 minutos e outra foi totalmente desmineralizada com 0,5M de EDTA por 15 dias. Os espécimes foram lavados e foi feita aplicação de 20 mg dos biovidros por 1minuto seguida de lavagem. Todos os espécimes foram armazenados em saliva artificial por 7 dias e então os testes FTIR, DRX, MFA, MEV/EDS foram realizados. Embora a concentração do biovidro no M-BAG seja 60%, ambas as formulações possuem potencial similar na remineralização da dentina.

Guo C, Xia Y, Niu P, Jiang L, Duan J, Yu Y, Zhou X, Li Y, Sun Z. Silica nanoparticles induce oxidative stress, inflammation, and endothelial dysfunction in vitro via activation of the MAPK/Nrf2 pathway and nuclear factor-κB signaling. Int J Nanomedicine. 2015 Feb 20;10:1463-77.

Neste estudo foi realizada cultura celular com células endoteliais da veia umbilical e observou-se que quando as células foram expostas à 12,5,25,50 e 100µg/ml de nanopartículas de sílica (58nm) por 24h a 37℃ a viabilidade celular diminuiu para 92,93%, 81,24%, 42,68% e 33,44% respectivamente. A viabilidade celular diminui com o tempo sugerindo que o tempo e a dose influenciam a toxicidade.

Migliore L, Uboldi C, Di Bucchianico S, Coppedè F. Nanomaterials and neurodegeneration. Environ Mol Mutagen. 2015 Mar;56(2):149-70.

Este artigo é uma revisão de literatura sobre os efeitos de nanomateriais no organismo. O uso de nanomateriais têm aumentado e esses materiais possuem efeitos adversos a saúde humana, pois podem entrar em contato com o organismo a partir da absorção pela pele, trato digestivo e inalação. E assim,algumas nanopartículas estão associadas com progressão de neurodegenerações como: Alzheimer, demência, Parkinson e esclerose lateral amiotrófica. Pequenas partículas de sílica podem causar citotoxicidade, estress oxidativo, respostas inflamatórias pulmonares e hepáticas. Em um estudo verificou-se que após insuflação nasal de nanopartículas de sílica em ratos houve acúmulo e defeitos no cérebro.

Li X, Wang J, Joiner A, Chang J. The remineralisation of enamel: a review of the literature. J Dent. 2014 Jun;42 Suppl 1:S12-20.

O esmalte está em íntimo contato com a saliva e a placa, e os cristais de HA estão em equilíbrio dinâmico com o meio. A saliva atua como tampão natural e neutralizante de ácidos, o pH menor que 5,5 leva a dissolução da hidroxiapatita. Há vários materiais sendo utilizados para remineralização do esmalte dental, dentre eles podemos citar fluoretos em diversas composições e princípios bioativos, como o biovidro 45S5 que foi descoberto em 1969 por Hench e Anderson.

Hannig M, Balz M. Influence of *in vivo* formed salivary pellicle on enamel erosion. Caries Res. 1999 Sep-Oct;33(5):372-9.

A saliva possui efeito importante para tamponamento e neutralização de ácidos, e a película salivar age como membrana semipermeável na superfície do esmalte provendo efeitos protetores contra desmineralização. Esse estudo avaliou o efeito protetor da película salivar *in vivo* durante 24horas ou 7 dias sobre o efeito de desmineralização com ácido cítrico (0,1%) por 30, 60 e 300 s. Os espécimes foram analisados por MEV/EDS e microdureza. Menor perda erosiva foi visualizada nos espécimes cobertos com a película adquirida. A película salivar pode resistir a ácidos e proporciona proteção ao esmalte frente a desafios erosivos.

Vollenweider M, Brunner TJ, Knecht S, Grass RN, Zehnder M, Imfeld T, Stark WJ. Remineralization of human dentin using ultrafine bioactive glass particles. Acta Biomater. 2007 Nov;3(6):936-43.

Após desmineralização com EDTA por 2horas, discos de dentina foram tratados com nanopartículas de biovidros (20-50 nm) ou partículas disponíveis comercialmente (90-710 μm) por um período de 1, 10 e 30 dias. Após a aplicação dos produtos remineralizantes pelos períodos determinados os espécimes foram analisados por espectroscopia Raman, MEV, EDS, análise termogravimétrica, resistência flexural e módulo de elasticidade, além da liberação de íons. A liberação de íons foi maior no grupo que utilizou partículas nanométricas e os resultados da espectroscopia de Raman após um dia já mostrou picos de fosfato apenas neste grupo. Todos os resultados deste estudo indicaram que maior taxa de remineralização é induzida por partículas de biovidro nanométricas.

Análise Estatística

Tests of Normality

Tratamento x Profundidade (µm)		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	DF	Valor p	Statistic	df	Valor p
Dureza (MPa)	Água / 20 µm	,224	5	0,2000	,922	5	0,5412
	Água / 45 µm	,179	5	0,2000	,966	5	0,8507
	Água / 70 µm	,192	5	0,2000	,942	5	0,6825
	Água / 100 µm	,229	5	0,2000	,960	5	0,8092
	Elmex / 20 µm	,200	5	0,2000	,979	5	0,9279
	Elmex / 45 µm	,346	5	0,0510	,779	5	0,0542
	Elmex / 70 µm	,169	5	0,2000	,970	5	0,8751
	Elmex / 100 µm	,247	5	0,2000	,877	5	0,2976
	Biovidro 45S5 / 20 µm	,250	5	0,2000	,841	5	0,1690
	Biovidro 45S5 / 45 µm	,331	5	0,0771	,819	5	0,1138
	Biovidro 45S5 / 70 µm	,322	5	0,0999	,892	5	0,3654
	Biovidro 45S5 / 100 µm	,225	5	0,2000	,929	5	0,5885
	Biovidro PCNSr / 20 µm	,281	5	0,2000	,905	5	0,4384
	Biovidro PCNSr / 45 µm	,231	5	0,2000	,913	5	0,4873
	Biovidro PCNSr / 70 µm	,205	5	0,2000	,976	5	0,9100
	Biovidro PCNSr / 100 µm	,293	5	0,1856	,857	5	0,2171
	Biovidro PCNSrTi / 20 µm	,218	5	0,2000	,898	5	0,3993
	Biovidro PCNSrTi / 45 µm	,289	5	0,1985	,898	5	0,3972
	Biovidro PCNSrTi / 70 µm	,305	5	0,1452	,808	5	0,0946
	Biovidro PCNSrTi / 100 µm	,203	5	0,2000	,946	5	0,7062
	Biovidro PCNSrMg / 20 µm	,230	5	0,2000	,943	5	0,6884
	Biovidro PCNSrMg / 45 µm	,311	5	0,1286	,882	5	0,3198
	Biovidro PCNSrMg / 70 µm	,281	5	0,2000	,864	5	0,2423
	Biovidro PCNSrMg / 100 µm	,240	5	0,2000	,863	5	0,2411
	Sem	,245	5	0,2000	,947	5	0,7125

	tratamento / 20 µm						
	Sem tratamento / 45 µm	,202	5	0,2000	,937	5	0,6478
	Sem tratamento / 70 µm	,170	5	0,2000	,980	5	0,9371
	Sem tratamento / 100 µm	,207	5	0,2000	,959	5	0,8003

a. Lilliefors Significance Correction

Descriptives

Dureza (MPa)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Água	20	146,6932	15,52912	3,47242	139,4253	153,9610	126,17	183,20
Elmex	20	243,6375	10,44608	2,33581	238,7486	248,5264	222,67	264,50
Biovidro 45S5	20	240,0575	15,53713	3,47421	232,7859	247,3291	219,60	269,70
Biovidro PCNSr	20	233,3850	13,53807	3,02720	227,0490	239,7210	213,20	264,40
Biovidro PCNSrTi	20	226,9600	15,16212	3,39035	219,8639	234,0561	204,00	266,80
Biovidro PCNSrMg	20	232,8150	17,65286	3,94730	224,5532	241,0768	204,30	267,20
Sem tratamento	20	260,1950	19,07309	4,26487	251,2685	269,1215	224,70	297,00
Total	140	226,2490	37,29192	3,15174	220,0175	232,4806	126,17	297,00

Test of Homogeneity of Variances

Dureza (MPa)

Levene Statistic	df1	df2	Valor p
1,152	6	133	,336

Descriptives

Dureza (MPa)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
20 µm	35	221,3213	37,84505	6,39698	208,3211	234,3216	126,17	287,50
45 µm	35	222,9095	36,60433	6,18726	210,3355	235,4836	126,60	283,20
70 µm	35	226,5657	37,51670	6,34148	213,6783	239,4532	129,67	282,30
100 µm	35	234,1995	37,47238	6,33399	221,3273	247,0717	135,17	297,00
Total	140	226,2490	37,29192	3,15174	220,0175	232,4806	126,17	297,00

Test of Homogeneity of Variances

Dureza (MPa)

Levene Statistic	df1	df2	Valor p
,069	3	136	,976

Descriptives

Dureza (MPa)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Água / 20 µm	5	139,4793	12,86375	5,75285	123,5069	155,4518	126,17	160,00
Água / 45 µm	5	146,3600	16,87533	7,54688	125,4065	167,3135	126,60	168,33
Água / 70 µm	5	144,6667	13,02517	5,82503	128,4938	160,8395	129,67	160,50
Água / 100 µm	5	156,2667	18,45765	8,25451	133,3485	179,1849	135,17	183,20
Elmex / 20 µm	5	234,9100	9,59645	4,29166	222,9944	246,8256	222,67	248,50
Elmex / 45 µm	5	239,3067	5,49856	2,45903	232,4793	246,1340	234,83	248,83
Elmex / 70 µm	5	245,2733	7,10389	3,17696	236,4527	254,0940	235,20	253,17
Elmex / 100 µm	5	255,0600	7,77419	3,47672	245,4071	264,7129	246,80	264,50
Biovidro 45S5 / 20 µm	5	238,3400	18,81563	8,41461	214,9773	261,7027	223,60	269,40
Biovidro 45S5 / 45 µm	5	235,4800	17,50020	7,82633	213,7506	257,2094	222,00	262,20
Biovidro 45S5 / 70 µm	5	240,7600	13,70595	6,12949	223,7418	257,7782	219,60	258,00
Biovidro 45S5 / 100 µm	5	245,6500	15,13052	6,76657	226,8630	264,4370	230,25	269,70
Biovidro PCNSr / 20 µm	5	230,8600	13,11328	5,86444	214,5777	247,1423	217,80	251,20
Biovidro PCNSr / 45 µm	5	237,1400	13,23662	5,91959	220,7046	253,5754	224,60	256,20
Biovidro PCNSr / 70 µm	5	230,0400	13,53248	6,05191	213,2372	246,8428	213,20	249,50
Biovidro PCNSr / 100 µm	5	235,5000	17,17877	7,68258	214,1697	256,8303	220,00	264,40
Biovidro PCNSrTi / 20 µm	5	223,1000	5,66039	2,53140	216,0717	230,1283	215,00	228,20
Biovidro PCNSrTi / 45 µm	5	223,3400	15,09463	6,75053	204,5975	242,0825	204,00	239,70
Biovidro PCNSrTi / 70 µm	5	226,7600	12,93263	5,78365	210,7020	242,8180	214,30	241,30
Biovidro PCNSrTi / 100 µm	5	234,6400	23,58078	10,54564	205,3606	263,9194	208,80	266,80
Biovidro PCNSrMg / 20 µm	5	226,4000	17,48185	7,81812	204,6934	248,1066	204,30	247,00
Biovidro PCNSrMg / 45 µm	5	219,6600	6,36695	2,84738	211,7544	227,5656	210,60	225,80
Biovidro PCNSrMg / 70 µm	5	237,5600	15,96756	7,14091	217,7337	257,3863	211,20	251,50
Biovidro PCNSrMg / 100 µm	5	247,6400	17,56326	7,85453	225,8323	269,4477	230,00	267,20
Sem tratamento / 20 µm	5	256,1600	20,50129	9,16846	230,7043	281,6157	233,00	287,50
Sem tratamento / 45 µm	5	259,0800	23,74357	10,61845	229,5985	288,5615	224,70	283,20
Sem tratamento / 70 µm	5	260,9000	15,39610	6,88535	241,7832	280,0168	241,80	282,30
Sem tratamento / 100 µm	5	264,6400	21,43929	9,58794	238,0196	291,2604	239,20	297,00
Total	140	226,2490	37,29192	3,15174	220,0175	232,4806	126,17	297,00

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Test of Homogeneity of Variances

Dureza (MPa)

Levene Statistic	df1	df2	Valor p
1,090	27	112	,365

Tests of Between-Subjects Effects

Dependent Variable: Dureza (MPa)

Source	Type III Sum of Squares	df	Mean Square	F	Valor p	Observed Power[b]
Tratamento	161380,730	6	26896,788	112,913	0,00000000	0,99996700
Profundidadeµm	589,752	3	196,584	4,836	0,48210604	0,22525420
Tratamento * Profundidadeµm	1789,432	18	99,413	,417	0,98173209	0,27224454
Error	26679,271	112	238,208			
Corrected Total	190439,185	139				

b. Computed using alpha = ,05

Tests of Between-Subjects Effects

Dependent Variable: Dureza (MPa)

Source	Type III Sum of Squares	df	Mean Square	F	Valor p	Observed Power[b]
TratamentoxProfundidade	166626,242	27	6171,342	25,907	0,00000000	0,99996702
Error	26679,271	112	238,208			
Corrected Total	193305,513	139				

b. Computed using alpha = ,05

Multiple Comparisons

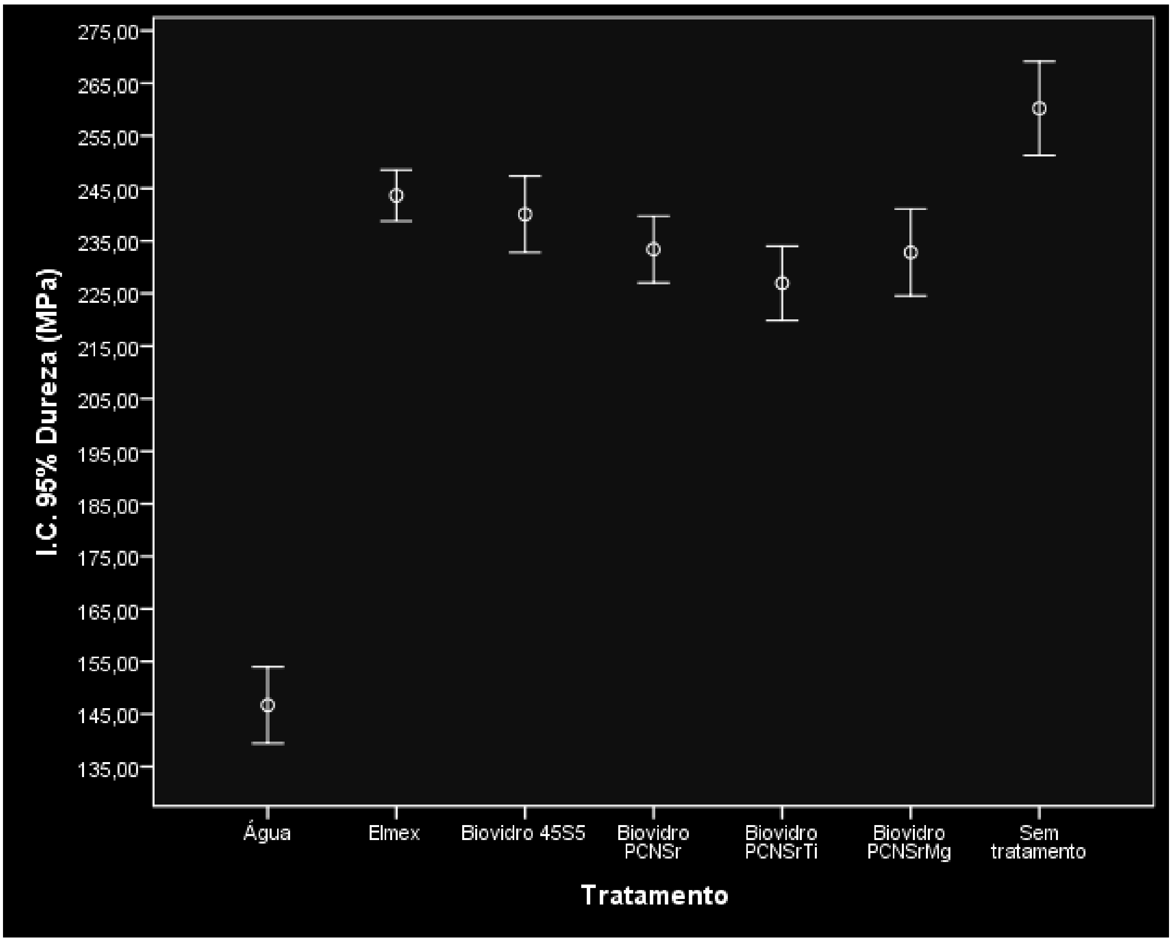
Dependent Variable: Dureza (MPa)

Tukey HSD

(I) Tratamento		Mean Difference (I-J)	Std. Error	Valor p	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Água	Elmex	-96,9443*	4,88065	0,0000	-111,5991	-82,2896
	Biovidro 45S5	-93,3643*	4,88065	0,0000	-108,0191	-78,7096
	Biovidro PCNSr	-86,6918*	4,88065	0,0000	-101,3466	-72,0371
	Biovidro PCNSrTi	-80,2668*	4,88065	0,0000	-94,9216	-65,6121
	Biovidro PCNSrMg	-86,1218*	4,88065	0,0000	-100,7766	-71,4671
	Sem tratamento	-113,5018*	4,88065	0,0000	-128,1566	-98,8471
Elmex	Água	96,9443*	4,88065	0,0000	82,2896	111,5991
	Biovidro 45S5	3,5800	4,88065	0,9902	-11,0748	18,2348
	Biovidro PCNSr	10,2525	4,88065	0,3595	-4,4023	24,9073
	Biovidro PCNSrTi	16,6775*	4,88065	0,0150	2,0227	31,3323
	Biovidro PCNSrMg	10,8225	4,88065	0,2947	-3,8323	25,4773
	Sem tratamento	-16,5575*	4,88065	0,0162	-31,2123	-1,9027
Biovidro 45S5	Água	93,3643*	4,88065	0,0000	78,7096	108,0191
	Elmex	-3,5800	4,88065	0,9902	-18,2348	11,0748
	Biovidro PCNSr	6,6725	4,88065	0,8179	-7,9823	21,3273
	Biovidro PCNSrTi	13,0975	4,88065	0,1121	-1,5573	27,7523
	Biovidro PCNSrMg	7,2425	4,88065	0,7538	-7,4123	21,8973
	Sem tratamento	-20,1375*	4,88065	0,0014	-34,7923	-5,4827
Biovidro PCNSr	Água	86,6918*	4,88065	0,0000	72,0371	101,3466
	Elmex	-10,2525	4,88065	0,3595	-24,9073	4,4023
	Biovidro 45S5	-6,6725	4,88065	0,8179	-21,3273	7,9823
	Biovidro PCNSrTi	6,4250	4,88065	0,8429	-8,2298	21,0798
	Biovidro PCNSrMg	,5700	4,88065	1,0000	-14,0848	15,2248
	Sem tratamento	-26,8100*	4,88065	0,0000	-41,4648	-12,1552
Biovidro PCNSrTi	Água	80,2668*	4,88065	0,0000	65,6121	94,9216
	Elmex	-16,6775*	4,88065	0,0150	-31,3323	-2,0227
	Biovidro 45S5	-13,0975	4,88065	0,1121	-27,7523	1,5573
	Biovidro PCNSr	-6,4250	4,88065	0,8429	-21,0798	8,2298
	Biovidro PCNSrMg	-5,8550	4,88065	0,8929	-20,5098	8,7998

	Sem tratamento	-33,2350*	4,88065	0,0000	-47,8898	-18,5802
Biovidro PCNSrMg	Água	86,1218*	4,88065	0,0000	71,4671	100,7766
	Elmex	-10,8225	4,88065	0,2947	-25,4773	3,8323
	Biovidro 45S5	-7,2425	4,88065	0,7538	-21,8973	7,4123
	Biovidro PCNSr	-,5700	4,88065	1,0000	-15,2248	14,0848
	Biovidro PCNSrTi	5,8550	4,88065	0,8929	-8,7998	20,5098
	Sem tratamento	-27,3800*	4,88065	0,0000	-42,0348	-12,7252
Sem tratamento	Água	113,5018*	4,88065	0,0000	98,8471	128,1566
	Elmex	16,5575*	4,88065	0,0162	1,9027	31,2123
	Biovidro 45S5	20,1375*	4,88065	0,0014	5,4827	34,7923
	Biovidro PCNSr	26,8100*	4,88065	0,0000	12,1552	41,4648
	Biovidro PCNSrTi	33,2350*	4,88065	0,0000	18,5802	47,8898
	Biovidro PCNSrMg	27,3800*	4,88065	0,0000	12,7252	42,0348

*. The mean difference is significant at the ,05 level.



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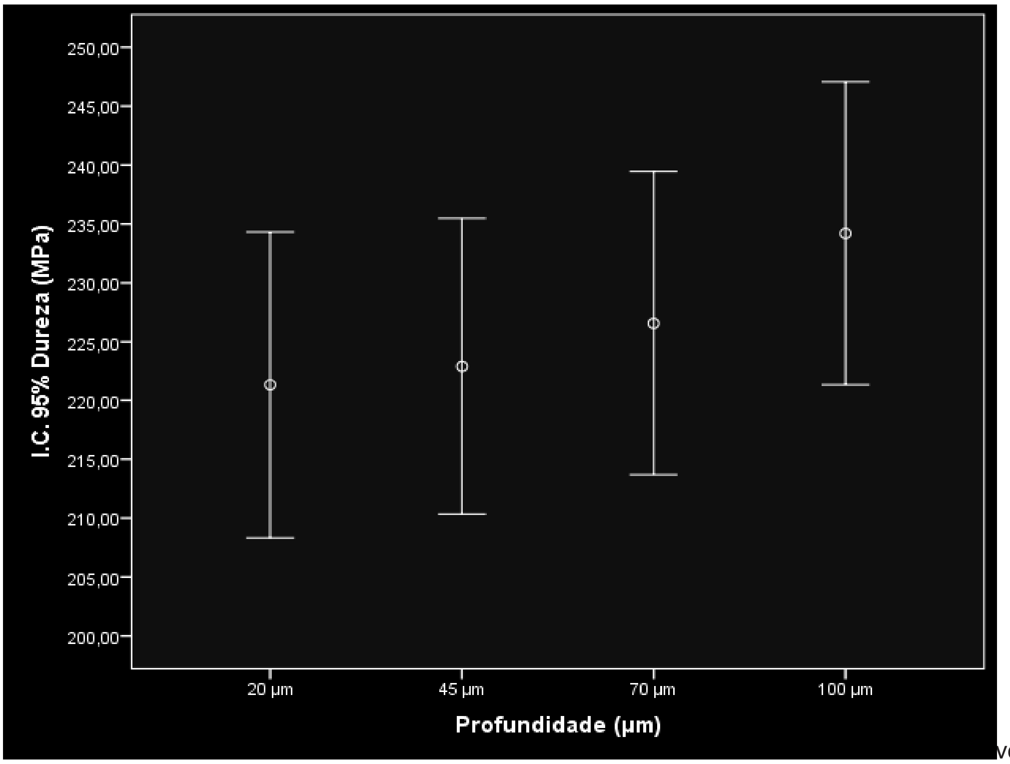
Multiple Comparisons

Dependent Variable: Dureza (MPa)

Tukey HSD

(I) Profundidade (µm)		Mean Difference (I-J)	Std. Error	Valor p	95% Confidence Interval	
					Lower Bound	Upper Bound
20 µm	45 µm	-1,5882	8,93133	0,9980	-24,8193	21,6429
	70 µm	-5,2444	8,93133	0,9358	-28,4755	17,9867
	100 µm	-12,8782	8,93133	0,4756	-36,1093	10,3529
45 µm	20 µm	1,5882	8,93133	0,9980	-21,6429	24,8193
	70 µm	-3,6562	8,93133	0,9768	-26,8873	19,5749
	100 µm	-11,2900	8,93133	0,5873	-34,5211	11,9411
70 µm	20 µm	5,2444	8,93133	0,9358	-17,9867	28,4755
	45 µm	3,6562	8,93133	0,9768	-19,5749	26,8873
	100 µm	-7,6338	8,93133	0,8280	-30,8649	15,5973
100 µm	20 µm	12,8782	8,93133	0,4756	-10,3529	36,1093
	45 µm	11,2900	8,93133	0,5873	-11,9411	34,5211
	70 µm	7,6338	8,93133	0,8280	-15,5973	30,8649

*. The mean difference is significant at the ,05 le



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Multiple Comparisons

Dependent Variable: Dureza (MPa)

Tukey HSD

(I) Tratamento x Profundidade (µm)		Mean Difference (I-J)	Std. Error	Valor p	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Água / 20 µm	Água / 45 µm	-6,88067	9,76131	1,0000	-44,0945	30,3332
	Água / 70 µm	-5,18733	9,76131	1,0000	-42,4012	32,0265
	Água / 100 µm	-16,78733	9,76131	0,9948	-54,0012	20,4265
	Elmex / 20 µm	-95,43067*	9,76131	0,0000	-132,6445	-58,2168
	Elmex / 45 µm	-99,82733*	9,76131	0,0000	-137,0412	-62,6135
	Elmex / 70 µm	-105,79400*	9,76131	0,0000	-143,0078	-68,5802
	Elmex / 100 µm	-115,58067*	9,76131	0,0000	-152,7945	-78,3668
	Biovidro 45S5 / 20 µm	-98,86067*	9,76131	0,0000	-136,0745	-61,6468
	Biovidro 45S5 / 45 µm	-96,00067*	9,76131	0,0000	-133,2145	-58,7868
	Biovidro 45S5 / 70 µm	-101,28067*	9,76131	0,0000	-138,4945	-64,0668
	Biovidro 45S5 / 100 µm	-106,17067*	9,76131	0,0000	-143,3845	-68,9568
	Biovidro PCNSr / 20 µm	-91,38067*	9,76131	0,0000	-128,5945	-54,1668
	Biovidro PCNSr / 45 µm	-97,66067*	9,76131	0,0000	-134,8745	-60,4468
	Biovidro PCNSr / 70 µm	-90,56067*	9,76131	0,0000	-127,7745	-53,3468

	Biovidro PCNSr / 100 µm	-96,02067*	9,76131	0,0000	-133,2345	-58,8068
	Biovidro PCNSrTi / 20 µm	-83,62067*	9,76131	0,0000	-120,8345	-46,4068
	Biovidro PCNSrTi / 45 µm	-83,86067*	9,76131	0,0000	-121,0745	-46,6468
	Biovidro PCNSrTi / 70 µm	-87,28067*	9,76131	0,0000	-124,4945	-50,0668
	Biovidro PCNSrTi / 100 µm	-95,16067*	9,76131	0,0000	-132,3745	-57,9468
	Biovidro PCNSrMg / 20 µm	-86,92067*	9,76131	0,0000	-124,1345	-49,7068
	Biovidro PCNSrMg / 45 µm	-80,18067*	9,76131	0,0000	-117,3945	-42,9668
	Biovidro PCNSrMg / 70 µm	-98,08067*	9,76131	0,0000	-135,2945	-60,8668
	Biovidro PCNSrMg / 100 µm	-108,16067*	9,76131	0,0000	-145,3745	-70,9468
	Sem tratamento / 20 µm	-116,68067*	9,76131	0,0000	-153,8945	-79,4668
	Sem tratamento / 45 µm	-119,60067*	9,76131	0,0000	-156,8145	-82,3868
	Sem tratamento / 70 µm	-121,42067*	9,76131	0,0000	-158,6345	-84,2068
	Sem tratamento / 100 µm	-125,16067*	9,76131	0,0000	-162,3745	-87,9468
Água / 45 µm	Água / 20 µm	6,88067	9,76131	1,0000	-30,3332	44,0945
	Água / 70 µm	1,69333	9,76131	1,0000	-35,5205	38,9072
	Água / 100 µm	-9,90667	9,76131	1,0000	-47,1205	27,3072
	Elmex / 20 µm	-88,55000*	9,76131	0,0000	-125,7638	-51,3362
	Elmex / 45 µm	-92,94667*	9,76131	0,0000	-130,1605	-55,7328
	Elmex / 70 µm	-98,91333*	9,76131	0,0000	-136,1272	-61,6995
	Elmex / 100 µm	-108,70000*	9,76131	0,0000	-145,9138	-71,4862
	Biovidro 45S5 / 20 µm	-91,98000*	9,76131	0,0000	-129,1938	-54,7662
	Biovidro 45S5 / 45 µm	-89,12000*	9,76131	0,0000	-126,3338	-51,9062
	Biovidro 45S5 / 70 µm	-94,40000*	9,76131	0,0000	-131,6138	-57,1862
	Biovidro 45S5 / 100 µm	-99,29000*	9,76131	0,0000	-136,5038	-62,0762
	Biovidro PCNSr / 20 µm	-84,50000*	9,76131	0,0000	-121,7138	-47,2862
	Biovidro PCNSr / 45 µm	-90,78000*	9,76131	0,0000	-127,9938	-53,5662
	Biovidro PCNSr / 70 µm	-83,68000*	9,76131	0,0000	-120,8938	-46,4662
	Biovidro PCNSr / 100 µm	-89,14000*	9,76131	0,0000	-126,3538	-51,9262
	Biovidro PCNSrTi / 20 µm	-76,74000*	9,76131	0,0000	-113,9538	-39,5262
	Biovidro PCNSrTi / 45 µm	-76,98000*	9,76131	0,0000	-114,1938	-39,7662
	Biovidro PCNSrTi / 70 µm	-80,40000*	9,76131	0,0000	-117,6138	-43,1862
	Biovidro PCNSrTi / 100 µm	-88,28000*	9,76131	0,0000	-125,4938	-51,0662

	Biovidro PCNSrMg / 20 µm	-80,04000*	9,76131	0,0000	-117,2538	-42,8262
	Biovidro PCNSrMg / 45 µm	-73,30000*	9,76131	0,0000	-110,5138	-36,0862
	Biovidro PCNSrMg / 70 µm	-91,20000*	9,76131	0,0000	-128,4138	-53,9862
	Biovidro PCNSrMg / 100 µm	-101,28000*	9,76131	0,0000	-138,4938	-64,0662
	Sem tratamento / 20 µm	-109,80000*	9,76131	0,0000	-147,0138	-72,5862
	Sem tratamento / 45 µm	-112,72000*	9,76131	0,0000	-149,9338	-75,5062
	Sem tratamento / 70 µm	-114,54000*	9,76131	0,0000	-151,7538	-77,3262
	Sem tratamento / 100 µm	-118,28000*	9,76131	0,0000	-155,4938	-81,0662
Água / 70 µm	Água / 20 µm	5,18733	9,76131	1,0000	-32,0265	42,4012
	Água / 45 µm	-1,69333	9,76131	1,0000	-38,9072	35,5205
	Água / 100 µm	-11,60000	9,76131	1,0000	-48,8138	25,6138
	Elmex / 20 µm	-90,24333*	9,76131	0,0000	-127,4572	-53,0295
	Elmex / 45 µm	-94,64000*	9,76131	0,0000	-131,8538	-57,4262
	Elmex / 70 µm	-100,60667*	9,76131	0,0000	-137,8205	-63,3928
	Elmex / 100 µm	-110,39333*	9,76131	0,0000	-147,6072	-73,1795
	Biovidro 45S5 / 20 µm	-93,67333*	9,76131	0,0000	-130,8872	-56,4595
	Biovidro 45S5 / 45 µm	-90,81333*	9,76131	0,0000	-128,0272	-53,5995
	Biovidro 45S5 / 70 µm	-96,09333*	9,76131	0,0000	-133,3072	-58,8795
	Biovidro 45S5 / 100 µm	-100,98333*	9,76131	0,0000	-138,1972	-63,7695
	Biovidro PCNSr / 20 µm	-86,19333*	9,76131	0,0000	-123,4072	-48,9795
	Biovidro PCNSr / 45 µm	-92,47333*	9,76131	0,0000	-129,6872	-55,2595
	Biovidro PCNSr / 70 µm	-85,37333*	9,76131	0,0000	-122,5872	-48,1595
	Biovidro PCNSr / 100 µm	-90,83333*	9,76131	0,0000	-128,0472	-53,6195
	Biovidro PCNSrTi / 20 µm	-78,43333*	9,76131	0,0000	-115,6472	-41,2195
	Biovidro PCNSrTi / 45 µm	-78,67333*	9,76131	0,0000	-115,8872	-41,4595
	Biovidro PCNSrTi / 70 µm	-82,09333*	9,76131	0,0000	-119,3072	-44,8795
	Biovidro PCNSrTi / 100 µm	-89,97333*	9,76131	0,0000	-127,1872	-52,7595
	Biovidro PCNSrMg / 20 µm	-81,73333*	9,76131	0,0000	-118,9472	-44,5195
	Biovidro PCNSrMg / 45 µm	-74,99333*	9,76131	0,0000	-112,2072	-37,7795
	Biovidro PCNSrMg / 70 µm	-92,89333*	9,76131	0,0000	-130,1072	-55,6795
	Biovidro PCNSrMg / 100 µm	-102,97333*	9,76131	0,0000	-140,1872	-65,7595
	Sem tratamento / 20 µm	-111,49333*	9,76131	0,0000	-148,7072	-74,2795
	Sem tratamento / 45	-114,41333*	9,76131		-151,6272	-77,1995

	µm			0,0000		
	Sem tratamento / 70 µm	-116,23333*	9,76131	0,0000	-153,4472	-79,0195
	Sem tratamento / 100 µm	-119,97333*	9,76131	0,0000	-157,1872	-82,7595
Água / 100 µm	Água / 20 µm	16,78733	9,76131	0,9948	-20,4265	54,0012
	Água / 45 µm	9,90667	9,76131	1,0000	-27,3072	47,1205
	Água / 70 µm	11,60000	9,76131	1,0000	-25,6138	48,8138
	Elmex / 20 µm	-78,64333*	9,76131	0,0000	-115,8572	-41,4295
	Elmex / 45 µm	-83,04000*	9,76131	0,0000	-120,2538	-45,8262
	Elmex / 70 µm	-89,00667*	9,76131	0,0000	-126,2205	-51,7928
	Elmex / 100 µm	-98,79333*	9,76131	0,0000	-136,0072	-61,5795
	Biovidro 45S5 / 20 µm	-82,07333*	9,76131	0,0000	-119,2872	-44,8595
	Biovidro 45S5 / 45 µm	-79,21333*	9,76131	0,0000	-116,4272	-41,9995
	Biovidro 45S5 / 70 µm	-84,49333*	9,76131	0,0000	-121,7072	-47,2795
	Biovidro 45S5 / 100 µm	-89,38333*	9,76131	0,0000	-126,5972	-52,1695
	Biovidro PCNSr / 20 µm	-74,59333*	9,76131	0,0000	-111,8072	-37,3795
	Biovidro PCNSr / 45 µm	-80,87333*	9,76131	0,0000	-118,0872	-43,6595
	Biovidro PCNSr / 70 µm	-73,77333*	9,76131	0,0000	-110,9872	-36,5595
	Biovidro PCNSr / 100 µm	-79,23333*	9,76131	0,0000	-116,4472	-42,0195
	Biovidro PCNSrTi / 20 µm	-66,83333*	9,76131	0,0000	-104,0472	-29,6195
	Biovidro PCNSrTi / 45 µm	-67,07333*	9,76131	0,0000	-104,2872	-29,8595
	Biovidro PCNSrTi / 70 µm	-70,49333*	9,76131	0,0000	-107,7072	-33,2795
	Biovidro PCNSrTi / 100 µm	-78,37333*	9,76131	0,0000	-115,5872	-41,1595
	Biovidro PCNSrMg / 20 µm	-70,13333*	9,76131	0,0000	-107,3472	-32,9195
	Biovidro PCNSrMg / 45 µm	-63,39333*	9,76131	0,0000	-100,6072	-26,1795
	Biovidro PCNSrMg / 70 µm	-81,29333*	9,76131	0,0000	-118,5072	-44,0795
	Biovidro PCNSrMg / 100 µm	-91,37333*	9,76131	0,0000	-128,5872	-54,1595
	Sem tratamento / 20 µm	-99,89333*	9,76131	0,0000	-137,1072	-62,6795
	Sem tratamento / 45 µm	-102,81333*	9,76131	0,0000	-140,0272	-65,5995
	Sem tratamento / 70 µm	-104,63333*	9,76131	0,0000	-141,8472	-67,4195
	Sem tratamento / 100 µm	-108,37333*	9,76131	0,0000	-145,5872	-71,1595
Elmex / 20 µm	Água / 20 µm	95,43067*	9,76131	0,0000	58,2168	132,6445
	Água / 45 µm	88,55000*	9,76131	0,0000	51,3362	125,7638
	Água / 70 µm	90,24333*	9,76131	0,0000	53,0295	127,4572

	Água / 100 µm	78,64333*	9,76131	0,0000	41,4295	115,8572
	Elmex / 45 µm	-4,39667	9,76131	1,0000	-41,6105	32,8172
	Elmex / 70 µm	-10,36333	9,76131	1,0000	-47,5772	26,8505
	Elmex / 100 µm	-20,15000	9,76131	0,9505	-57,3638	17,0638
	Biovidro 45S5 / 20 µm	-3,43000	9,76131	1,0000	-40,6438	33,7838
	Biovidro 45S5 / 45 µm	-,57000	9,76131	1,0000	-37,7838	36,6438
	Biovidro 45S5 / 70 µm	-5,85000	9,76131	1,0000	-43,0638	31,3638
	Biovidro 45S5 / 100 µm	-10,74000	9,76131	1,0000	-47,9538	26,4738
	Biovidro PCNSr / 20 µm	4,05000	9,76131	1,0000	-33,1638	41,2638
	Biovidro PCNSr / 45 µm	-2,23000	9,76131	1,0000	-39,4438	34,9838
	Biovidro PCNSr / 70 µm	4,87000	9,76131	1,0000	-32,3438	42,0838
	Biovidro PCNSr / 100 µm	-,59000	9,76131	1,0000	-37,8038	36,6238
	Biovidro PCNSrTi / 20 µm	11,81000	9,76131	1,0000	-25,4038	49,0238
	Biovidro PCNSrTi / 45 µm	11,57000	9,76131	1,0000	-25,6438	48,7838
	Biovidro PCNSrTi / 70 µm	8,15000	9,76131	1,0000	-29,0638	45,3638
	Biovidro PCNSrTi / 100 µm	,27000	9,76131	1,0000	-36,9438	37,4838
	Biovidro PCNSrMg / 20 µm	8,51000	9,76131	1,0000	-28,7038	45,7238
	Biovidro PCNSrMg / 45 µm	15,25000	9,76131	0,9988	-21,9638	52,4638
	Biovidro PCNSrMg / 70 µm	-2,65000	9,76131	1,0000	-39,8638	34,5638
	Biovidro PCNSrMg / 100 µm	-12,73000	9,76131	0,9999	-49,9438	24,4838
	Sem tratamento / 20 µm	-21,25000	9,76131	0,9156	-58,4638	15,9638
	Sem tratamento / 45 µm	-24,17000	9,76131	0,7589	-61,3838	13,0438
	Sem tratamento / 70 µm	-25,99000	9,76131	0,6244	-63,2038	11,2238
	Sem tratamento / 100 µm	-29,73000	9,76131	0,3419	-66,9438	7,4838
Elmex / 45 µm	Água / 20 µm	99,82733*	9,76131	0,0000	62,6135	137,0412
	Água / 45 µm	92,94667*	9,76131	0,0000	55,7328	130,1605
	Água / 70 µm	94,64000*	9,76131	0,0000	57,4262	131,8538
	Água / 100 µm	83,04000*	9,76131	0,0000	45,8262	120,2538
	Elmex / 20 µm	4,39667	9,76131	1,0000	-32,8172	41,6105
	Elmex / 70 µm	-5,96667	9,76131	1,0000	-43,1805	31,2472
	Elmex / 100 µm	-15,75333	9,76131	0,9980	-52,9672	21,4605
	Biovidro 45S5 / 20 µm	,96667	9,76131	1,0000	-36,2472	38,1805
	Biovidro 45S5 / 45 µm	3,82667	9,76131	1,0000	-33,3872	41,0405

	Biovidro 45S5 / 70 µm	-1,45333	9,76131	1,0000	-38,6672	35,7605
	Biovidro 45S5 / 100 µm	-6,34333	9,76131	1,0000	-43,5572	30,8705
	Biovidro PCNSr / 20 µm	8,44667	9,76131	1,0000	-28,7672	45,6605
	Biovidro PCNSr / 45 µm	2,16667	9,76131	1,0000	-35,0472	39,3805
	Biovidro PCNSr / 70 µm	9,26667	9,76131	1,0000	-27,9472	46,4805
	Biovidro PCNSr / 100 µm	3,80667	9,76131	1,0000	-33,4072	41,0205
	Biovidro PCNSrTi / 20 µm	16,20667	9,76131	0,9969	-21,0072	53,4205
	Biovidro PCNSrTi / 45 µm	15,96667	9,76131	0,9975	-21,2472	53,1805
	Biovidro PCNSrTi / 70 µm	12,54667	9,76131	1,0000	-24,6672	49,7605
	Biovidro PCNSrTi / 100 µm	4,66667	9,76131	1,0000	-32,5472	41,8805
	Biovidro PCNSrMg / 20 µm	12,90667	9,76131	0,9999	-24,3072	50,1205
	Biovidro PCNSrMg / 45 µm	19,64667	9,76131	0,9624	-17,5672	56,8605
	Biovidro PCNSrMg / 70 µm	1,74667	9,76131	1,0000	-35,4672	38,9605
	Biovidro PCNSrMg / 100 µm	-8,33333	9,76131	1,0000	-45,5472	28,8805
	Sem tratamento / 20 µm	-16,85333	9,76131	0,9946	-54,0672	20,3605
	Sem tratamento / 45 µm	-19,77333	9,76131	0,9596	-56,9872	17,4405
	Sem tratamento / 70 µm	-21,59333	9,76131	0,9020	-58,8072	15,6205
	Sem tratamento / 100 µm	-25,33333	9,76131	0,6749	-62,5472	11,8805
Elmex / 70 µm	Água / 20 µm	105,79400*	9,76131	0,0000	68,5802	143,0078
	Água / 45 µm	98,91333*	9,76131	0,0000	61,6995	136,1272
	Água / 70 µm	100,60667*	9,76131	0,0000	63,3928	137,8205
	Água / 100 µm	89,00667*	9,76131	0,0000	51,7928	126,2205
	Elmex / 20 µm	10,36333	9,76131	1,0000	-26,8505	47,5772
	Elmex / 45 µm	5,96667	9,76131	1,0000	-31,2472	43,1805
	Elmex / 100 µm	-9,78667	9,76131	1,0000	-47,0005	27,4272
	Biovidro 45S5 / 20 µm	6,93333	9,76131	1,0000	-30,2805	44,1472
	Biovidro 45S5 / 45 µm	9,79333	9,76131	1,0000	-27,4205	47,0072
	Biovidro 45S5 / 70 µm	4,51333	9,76131	1,0000	-32,7005	41,7272
	Biovidro 45S5 / 100 µm	-,37667	9,76131	1,0000	-37,5905	36,8372
	Biovidro PCNSr / 20 µm	14,41333	9,76131	0,9995	-22,8005	51,6272
	Biovidro PCNSr / 45 µm	8,13333	9,76131	1,0000	-29,0805	45,3472
	Biovidro PCNSr / 70 µm	15,23333	9,76131	0,9988	-21,9805	52,4472
	Biovidro PCNSr / 100 µm	9,77333	9,76131	1,0000	-27,4405	46,9872

	Biovidro PCNSrTi / 20 µm	22,17333	9,76131	0,8760	-15,0405	59,3872
	Biovidro PCNSrTi / 45 µm	21,93333	9,76131	0,8873	-15,2805	59,1472
	Biovidro PCNSrTi / 70 µm	18,51333	9,76131	0,9812	-18,7005	55,7272
	Biovidro PCNSrTi / 100 µm	10,63333	9,76131	1,0000	-26,5805	47,8472
	Biovidro PCNSrMg / 20 µm	18,87333	9,76131	0,9763	-18,3405	56,0872
	Biovidro PCNSrMg / 45 µm	25,61333	9,76131	0,6536	-11,6005	62,8272
	Biovidro PCNSrMg / 70 µm	7,71333	9,76131	1,0000	-29,5005	44,9272
	Biovidro PCNSrMg / 100 µm	-2,36667	9,76131	1,0000	-39,5805	34,8472
	Sem tratamento / 20 µm	-10,88667	9,76131	1,0000	-48,1005	26,3272
	Sem tratamento / 45 µm	-13,80667	9,76131	0,9998	-51,0205	23,4072
	Sem tratamento / 70 µm	-15,62667	9,76131	0,9982	-52,8405	21,5872
	Sem tratamento / 100 µm	-19,36667	9,76131	0,9680	-56,5805	17,8472
Elmex / 100 µm	Água / 20 µm	115,58067*	9,76131	0,0000	78,3668	152,7945
	Água / 45 µm	108,70000*	9,76131	0,0000	71,4862	145,9138
	Água / 70 µm	110,39333*	9,76131	0,0000	73,1795	147,6072
	Água / 100 µm	98,79333*	9,76131	0,0000	61,5795	136,0072
	Elmex / 20 µm	20,15000	9,76131	0,9505	-17,0638	57,3638
	Elmex / 45 µm	15,75333	9,76131	0,9980	-21,4605	52,9672
	Elmex / 70 µm	9,78667	9,76131	1,0000	-27,4272	47,0005
	Biovidro 45S5 / 20 µm	16,72000	9,76131	0,9951	-20,4938	53,9338
	Biovidro 45S5 / 45 µm	19,58000	9,76131	0,9638	-17,6338	56,7938
	Biovidro 45S5 / 70 µm	14,30000	9,76131	0,9996	-22,9138	51,5138
	Biovidro 45S5 / 100 µm	9,41000	9,76131	1,0000	-27,8038	46,6238
	Biovidro PCNSr / 20 µm	24,20000	9,76131	0,7569	-13,0138	61,4138
	Biovidro PCNSr / 45 µm	17,92000	9,76131	0,9875	-19,2938	55,1338
	Biovidro PCNSr / 70 µm	25,02000	9,76131	0,6984	-12,1938	62,2338
	Biovidro PCNSr / 100 µm	19,56000	9,76131	0,9642	-17,6538	56,7738
	Biovidro PCNSrTi / 20 µm	31,96000	9,76131	0,2112	-5,2538	69,1738
	Biovidro PCNSrTi / 45 µm	31,72000	9,76131	0,2234	-5,4938	68,9338
	Biovidro PCNSrTi / 70 µm	28,30000	9,76131	0,4442	-8,9138	65,5138
	Biovidro PCNSrTi / 100 µm	20,42000	9,76131	0,9431	-16,7938	57,6338
	Biovidro PCNSrMg / 20 µm	28,66000	9,76131	0,4174	-8,5538	65,8738

	Biovidro PCNSrMg / 45 µm	35,40000	9,76131	0,0859	-1,8138	72,6138
	Biovidro PCNSrMg / 70 µm	17,50000	9,76131	0,9909	-19,7138	54,7138
	Biovidro PCNSrMg / 100 µm	7,42000	9,76131	1,0000	-29,7938	44,6338
	Sem tratamento / 20 µm	-1,10000	9,76131	1,0000	-38,3138	36,1138
	Sem tratamento / 45 µm	-4,02000	9,76131	1,0000	-41,2338	33,1938
	Sem tratamento / 70 µm	-5,84000	9,76131	1,0000	-43,0538	31,3738
	Sem tratamento / 100 µm	-9,58000	9,76131	1,0000	-46,7938	27,6338
Biovidro 45S5 / 20 µm	Água / 20 µm	98,86067*	9,76131	0,0000	61,6468	136,0745
	Água / 45 µm	91,98000*	9,76131	0,0000	54,7662	129,1938
	Água / 70 µm	93,67333*	9,76131	0,0000	56,4595	130,8872
	Água / 100 µm	82,07333*	9,76131	0,0000	44,8595	119,2872
	Elmex / 20 µm	3,43000	9,76131	1,0000	-33,7838	40,6438
	Elmex / 45 µm	-,96667	9,76131	1,0000	-38,1805	36,2472
	Elmex / 70 µm	-6,93333	9,76131	1,0000	-44,1472	30,2805
	Elmex / 100 µm	-16,72000	9,76131	0,9951	-53,9338	20,4938
	Biovidro 45S5 / 45 µm	2,86000	9,76131	1,0000	-34,3538	40,0738
	Biovidro 45S5 / 70 µm	-2,42000	9,76131	1,0000	-39,6338	34,7938
	Biovidro 45S5 / 100 µm	-7,31000	9,76131	1,0000	-44,5238	29,9038
	Biovidro PCNSr / 20 µm	7,48000	9,76131	1,0000	-29,7338	44,6938
	Biovidro PCNSr / 45 µm	1,20000	9,76131	1,0000	-36,0138	38,4138
	Biovidro PCNSr / 70 µm	8,30000	9,76131	1,0000	-28,9138	45,5138
	Biovidro PCNSr / 100 µm	2,84000	9,76131	1,0000	-34,3738	40,0538
	Biovidro PCNSrTi / 20 µm	15,24000	9,76131	0,9988	-21,9738	52,4538
	Biovidro PCNSrTi / 45 µm	15,00000	9,76131	0,9991	-22,2138	52,2138
	Biovidro PCNSrTi / 70 µm	11,58000	9,76131	1,0000	-25,6338	48,7938
	Biovidro PCNSrTi / 100 µm	3,70000	9,76131	1,0000	-33,5138	40,9138
	Biovidro PCNSrMg / 20 µm	11,94000	9,76131	1,0000	-25,2738	49,1538
	Biovidro PCNSrMg / 45 µm	18,68000	9,76131	0,9790	-18,5338	55,8938
	Biovidro PCNSrMg / 70 µm	,78000	9,76131	1,0000	-36,4338	37,9938
	Biovidro PCNSrMg / 100 µm	-9,30000	9,76131	1,0000	-46,5138	27,9138
	Sem tratamento / 20 µm	-17,82000	9,76131	0,9884	-55,0338	19,3938
	Sem tratamento / 45 µm	-20,74000	9,76131	0,9334	-57,9538	16,4738
	Sem tratamento / 70	-22,56000	9,76131		-59,7738	14,6538

	µm			0,8566		
	Sem tratamento / 100 µm	-26,30000	9,76131	0,6001	-63,5138	10,9138
Biovidro 45S5 / 45 µm	Água / 20 µm	96,00067*	9,76131	0,0000	58,7868	133,2145
	Água / 45 µm	89,12000*	9,76131	0,0000	51,9062	126,3338
	Água / 70 µm	90,81333*	9,76131	0,0000	53,5995	128,0272
	Água / 100 µm	79,21333*	9,76131	0,0000	41,9995	116,4272
	Elmex / 20 µm	,57000	9,76131	1,0000	-36,6438	37,7838
	Elmex / 45 µm	-3,82667	9,76131	1,0000	-41,0405	33,3872
	Elmex / 70 µm	-9,79333	9,76131	1,0000	-47,0072	27,4205
	Elmex / 100 µm	-19,58000	9,76131	0,9638	-56,7938	17,6338
	Biovidro 45S5 / 20 µm	-2,86000	9,76131	1,0000	-40,0738	34,3538
	Biovidro 45S5 / 70 µm	-5,28000	9,76131	1,0000	-42,4938	31,9338
	Biovidro 45S5 / 100 µm	-10,17000	9,76131	1,0000	-47,3838	27,0438
	Biovidro PCNSr / 20 µm	4,62000	9,76131	1,0000	-32,5938	41,8338
	Biovidro PCNSr / 45 µm	-1,66000	9,76131	1,0000	-38,8738	35,5538
	Biovidro PCNSr / 70 µm	5,44000	9,76131	1,0000	-31,7738	42,6538
	Biovidro PCNSr / 100 µm	-,02000	9,76131	1,0000	-37,2338	37,1938
	Biovidro PCNSrTi / 20 µm	12,38000	9,76131	1,0000	-24,8338	49,5938
	Biovidro PCNSrTi / 45 µm	12,14000	9,76131	1,0000	-25,0738	49,3538
	Biovidro PCNSrTi / 70 µm	8,72000	9,76131	1,0000	-28,4938	45,9338
	Biovidro PCNSrTi / 100 µm	,84000	9,76131	1,0000	-36,3738	38,0538
	Biovidro PCNSrMg / 20 µm	9,08000	9,76131	1,0000	-28,1338	46,2938
	Biovidro PCNSrMg / 45 µm	15,82000	9,76131	0,9978	-21,3938	53,0338
	Biovidro PCNSrMg / 70 µm	-2,08000	9,76131	1,0000	-39,2938	35,1338
	Biovidro PCNSrMg / 100 µm	-12,16000	9,76131	1,0000	-49,3738	25,0538
	Sem tratamento / 20 µm	-20,68000	9,76131	0,9353	-57,8938	16,5338
	Sem tratamento / 45 µm	-23,60000	9,76131	0,7964	-60,8138	13,6138
	Sem tratamento / 70 µm	-25,42000	9,76131	0,6683	-62,6338	11,7938
	Sem tratamento / 100 µm	-29,16000	9,76131	0,3812	-66,3738	8,0538
Biovidro 45S5 / 70 µm	Água / 20 µm	101,28067*	9,76131	0,0000	64,0668	138,4945
	Água / 45 µm	94,40000*	9,76131	0,0000	57,1862	131,6138
	Água / 70 µm	96,09333*	9,76131	0,0000	58,8795	133,3072
	Água / 100 µm	84,49333*	9,76131	0,0000	47,2795	121,7072

	Elmex / 20 µm	5,85000	9,76131	1,0000	-31,3638	43,0638
	Elmex / 45 µm	1,45333	9,76131	1,0000	-35,7605	38,6672
	Elmex / 70 µm	-4,51333	9,76131	1,0000	-41,7272	32,7005
	Elmex / 100 µm	-14,30000	9,76131	0,9996	-51,5138	22,9138
	Biovidro 45S5 / 20 µm	2,42000	9,76131	1,0000	-34,7938	39,6338
	Biovidro 45S5 / 45 µm	5,28000	9,76131	1,0000	-31,9338	42,4938
	Biovidro 45S5 / 100 µm	-4,89000	9,76131	1,0000	-42,1038	32,3238
	Biovidro PCNSr / 20 µm	9,90000	9,76131	1,0000	-27,3138	47,1138
	Biovidro PCNSr / 45 µm	3,62000	9,76131	1,0000	-33,5938	40,8338
	Biovidro PCNSr / 70 µm	10,72000	9,76131	1,0000	-26,4938	47,9338
	Biovidro PCNSr / 100 µm	5,26000	9,76131	1,0000	-31,9538	42,4738
	Biovidro PCNSrTi / 20 µm	17,66000	9,76131	0,9897	-19,5538	54,8738
	Biovidro PCNSrTi / 45 µm	17,42000	9,76131	0,9914	-19,7938	54,6338
	Biovidro PCNSrTi / 70 µm	14,00000	9,76131	0,9997	-23,2138	51,2138
	Biovidro PCNSrTi / 100 µm	6,12000	9,76131	1,0000	-31,0938	43,3338
	Biovidro PCNSrMg / 20 µm	14,36000	9,76131	0,9995	-22,8538	51,5738
	Biovidro PCNSrMg / 45 µm	21,10000	9,76131	0,9211	-16,1138	58,3138
	Biovidro PCNSrMg / 70 µm	3,20000	9,76131	1,0000	-34,0138	40,4138
	Biovidro PCNSrMg / 100 µm	-6,88000	9,76131	1,0000	-44,0938	30,3338
	Sem tratamento / 20 µm	-15,40000	9,76131	0,9986	-52,6138	21,8138
	Sem tratamento / 45 µm	-18,32000	9,76131	0,9835	-55,5338	18,8938
	Sem tratamento / 70 µm	-20,14000	9,76131	0,9508	-57,3538	17,0738
	Sem tratamento / 100 µm	-23,88000	9,76131	0,7783	-61,0938	13,3338
Biovidro 45S5 / 100 µm	Água / 20 µm	106,17067*	9,76131	0,0000	68,9568	143,3845
	Água / 45 µm	99,29000*	9,76131	0,0000	62,0762	136,5038
	Água / 70 µm	100,98333*	9,76131	0,0000	63,7695	138,1972
	Água / 100 µm	89,38333*	9,76131	0,0000	52,1695	126,5972
	Elmex / 20 µm	10,74000	9,76131	1,0000	-26,4738	47,9538
	Elmex / 45 µm	6,34333	9,76131	1,0000	-30,8705	43,5572
	Elmex / 70 µm	,37667	9,76131	1,0000	-36,8372	37,5905
	Elmex / 100 µm	-9,41000	9,76131	1,0000	-46,6238	27,8038
	Biovidro 45S5 / 20 µm	7,31000	9,76131	1,0000	-29,9038	44,5238
	Biovidro 45S5 / 45 µm	10,17000	9,76131	1,0000	-27,0438	47,3838

	Biovidro 45S5 / 70 µm	4,89000	9,76131	1,0000	-32,3238	42,1038
	Biovidro PCNSr / 20 µm	14,79000	9,76131	0,9993	-22,4238	52,0038
	Biovidro PCNSr / 45 µm	8,51000	9,76131	1,0000	-28,7038	45,7238
	Biovidro PCNSr / 70 µm	15,61000	9,76131	0,9982	-21,6038	52,8238
	Biovidro PCNSr / 100 µm	10,15000	9,76131	1,0000	-27,0638	47,3638
	Biovidro PCNSrTi / 20 µm	22,55000	9,76131	0,8571	-14,6638	59,7638
	Biovidro PCNSrTi / 45 µm	22,31000	9,76131	0,8694	-14,9038	59,5238
	Biovidro PCNSrTi / 70 µm	18,89000	9,76131	0,9760	-18,3238	56,1038
	Biovidro PCNSrTi / 100 µm	11,01000	9,76131	1,0000	-26,2038	48,2238
	Biovidro PCNSrMg / 20 µm	19,25000	9,76131	0,9701	-17,9638	56,4638
	Biovidro PCNSrMg / 45 µm	25,99000	9,76131	0,6244	-11,2238	63,2038
	Biovidro PCNSrMg / 70 µm	8,09000	9,76131	1,0000	-29,1238	45,3038
	Biovidro PCNSrMg / 100 µm	-1,99000	9,76131	1,0000	-39,2038	35,2238
	Sem tratamento / 20 µm	-10,51000	9,76131	1,0000	-47,7238	26,7038
	Sem tratamento / 45 µm	-13,43000	9,76131	0,9999	-50,6438	23,7838
	Sem tratamento / 70 µm	-15,25000	9,76131	0,9988	-52,4638	21,9638
	Sem tratamento / 100 µm	-18,99000	9,76131	0,9745	-56,2038	18,2238
Biovidro PCNSr / 20 µm	Água / 20 µm	91,38067*	9,76131	0,0000	54,1668	128,5945
	Água / 45 µm	84,50000*	9,76131	0,0000	47,2862	121,7138
	Água / 70 µm	86,19333*	9,76131	0,0000	48,9795	123,4072
	Água / 100 µm	74,59333*	9,76131	0,0000	37,3795	111,8072
	Elmex / 20 µm	-4,05000	9,76131	1,0000	-41,2638	33,1638
	Elmex / 45 µm	-8,44667	9,76131	1,0000	-45,6605	28,7672
	Elmex / 70 µm	-14,41333	9,76131	0,9995	-51,6272	22,8005
	Elmex / 100 µm	-24,20000	9,76131	0,7569	-61,4138	13,0138
	Biovidro 45S5 / 20 µm	-7,48000	9,76131	1,0000	-44,6938	29,7338
	Biovidro 45S5 / 45 µm	-4,62000	9,76131	1,0000	-41,8338	32,5938
	Biovidro 45S5 / 70 µm	-9,90000	9,76131	1,0000	-47,1138	27,3138
	Biovidro 45S5 / 100 µm	-14,79000	9,76131	0,9993	-52,0038	22,4238
	Biovidro PCNSr / 45 µm	-6,28000	9,76131	1,0000	-43,4938	30,9338
	Biovidro PCNSr / 70 µm	,82000	9,76131	1,0000	-36,3938	38,0338
	Biovidro PCNSr / 100 µm	-4,64000	9,76131	1,0000	-41,8538	32,5738
	Biovidro PCNSrTi / 20 µm	7,76000	9,76131	1,0000	-29,4538	44,9738

	Biovidro PCNSrTi / 45 µm	7,52000	9,76131	1,0000	-29,6938	44,7338
	Biovidro PCNSrTi / 70 µm	4,10000	9,76131	1,0000	-33,1138	41,3138
	Biovidro PCNSrTi / 100 µm	-3,78000	9,76131	1,0000	-40,9938	33,4338
	Biovidro PCNSrMg / 20 µm	4,46000	9,76131	1,0000	-32,7538	41,6738
	Biovidro PCNSrMg / 45 µm	11,20000	9,76131	1,0000	-26,0138	48,4138
	Biovidro PCNSrMg / 70 µm	-6,70000	9,76131	1,0000	-43,9138	30,5138
	Biovidro PCNSrMg / 100 µm	-16,78000	9,76131	0,9949	-53,9938	20,4338
	Sem tratamento / 20 µm	-25,30000	9,76131	0,6774	-62,5138	11,9138
	Sem tratamento / 45 µm	-28,22000	9,76131	0,4502	-65,4338	8,9938
	Sem tratamento / 70 µm	-30,04000	9,76131	0,3214	-67,2538	7,1738
	Sem tratamento / 100 µm	-33,78000	9,76131	0,1342	-70,9938	3,4338
Biovidro PCNSr / 45 µm	Água / 20 µm	97,66067*	9,76131	0,0000	60,4468	134,8745
	Água / 45 µm	90,78000*	9,76131	0,0000	53,5662	127,9938
	Água / 70 µm	92,47333*	9,76131	0,0000	55,2595	129,6872
	Água / 100 µm	80,87333*	9,76131	0,0000	43,6595	118,0872
	Elmex / 20 µm	2,23000	9,76131	1,0000	-34,9838	39,4438
	Elmex / 45 µm	-2,16667	9,76131	1,0000	-39,3805	35,0472
	Elmex / 70 µm	-8,13333	9,76131	1,0000	-45,3472	29,0805
	Elmex / 100 µm	-17,92000	9,76131	0,9875	-55,1338	19,2938
	Biovidro 45S5 / 20 µm	-1,20000	9,76131	1,0000	-38,4138	36,0138
	Biovidro 45S5 / 45 µm	1,66000	9,76131	1,0000	-35,5538	38,8738
	Biovidro 45S5 / 70 µm	-3,62000	9,76131	1,0000	-40,8338	33,5938
	Biovidro 45S5 / 100 µm	-8,51000	9,76131	1,0000	-45,7238	28,7038
	Biovidro PCNSr / 20 µm	6,28000	9,76131	1,0000	-30,9338	43,4938
	Biovidro PCNSr / 70 µm	7,10000	9,76131	1,0000	-30,1138	44,3138
	Biovidro PCNSr / 100 µm	1,64000	9,76131	1,0000	-35,5738	38,8538
	Biovidro PCNSrTi / 20 µm	14,04000	9,76131	0,9997	-23,1738	51,2538
	Biovidro PCNSrTi / 45 µm	13,80000	9,76131	0,9998	-23,4138	51,0138
	Biovidro PCNSrTi / 70 µm	10,38000	9,76131	1,0000	-26,8338	47,5938
	Biovidro PCNSrTi / 100 µm	2,50000	9,76131	1,0000	-34,7138	39,7138
	Biovidro PCNSrMg / 20 µm	10,74000	9,76131	1,0000	-26,4738	47,9538
	Biovidro PCNSrMg / 45 µm	17,48000	9,76131	0,9910	-19,7338	54,6938

	Biovidro PCNSrMg / 70 µm	-,42000	9,76131	1,0000	-37,6338	36,7938
	Biovidro PCNSrMg / 100 µm	-10,50000	9,76131	1,0000	-47,7138	26,7138
	Sem tratamento / 20 µm	-19,02000	9,76131	0,9740	-56,2338	18,1938
	Sem tratamento / 45 µm	-21,94000	9,76131	0,8870	-59,1538	15,2738
	Sem tratamento / 70 µm	-23,76000	9,76131	0,7862	-60,9738	13,4538
	Sem tratamento / 100 µm	-27,50000	9,76131	0,5057	-64,7138	9,7138
Biovidro PCNSr / 70 µm	Água / 20 µm	90,56067*	9,76131	0,0000	53,3468	127,7745
	Água / 45 µm	83,68000*	9,76131	0,0000	46,4662	120,8938
	Água / 70 µm	85,37333*	9,76131	0,0000	48,1595	122,5872
	Água / 100 µm	73,77333*	9,76131	0,0000	36,5595	110,9872
	Elmex / 20 µm	-4,87000	9,76131	1,0000	-42,0838	32,3438
	Elmex / 45 µm	-9,26667	9,76131	1,0000	-46,4805	27,9472
	Elmex / 70 µm	-15,23333	9,76131	0,9988	-52,4472	21,9805
	Elmex / 100 µm	-25,02000	9,76131	0,6984	-62,2338	12,1938
	Biovidro 45S5 / 20 µm	-8,30000	9,76131	1,0000	-45,5138	28,9138
	Biovidro 45S5 / 45 µm	-5,44000	9,76131	1,0000	-42,6538	31,7738
	Biovidro 45S5 / 70 µm	-10,72000	9,76131	1,0000	-47,9338	26,4938
	Biovidro 45S5 / 100 µm	-15,61000	9,76131	0,9982	-52,8238	21,6038
	Biovidro PCNSr / 20 µm	-,82000	9,76131	1,0000	-38,0338	36,3938
	Biovidro PCNSr / 45 µm	-7,10000	9,76131	1,0000	-44,3138	30,1138
	Biovidro PCNSr / 100 µm	-5,46000	9,76131	1,0000	-42,6738	31,7538
	Biovidro PCNSrTi / 20 µm	6,94000	9,76131	1,0000	-30,2738	44,1538
	Biovidro PCNSrTi / 45 µm	6,70000	9,76131	1,0000	-30,5138	43,9138
	Biovidro PCNSrTi / 70 µm	3,28000	9,76131	1,0000	-33,9338	40,4938
	Biovidro PCNSrTi / 100 µm	-4,60000	9,76131	1,0000	-41,8138	32,6138
	Biovidro PCNSrMg / 20 µm	3,64000	9,76131	1,0000	-33,5738	40,8538
	Biovidro PCNSrMg / 45 µm	10,38000	9,76131	1,0000	-26,8338	47,5938
	Biovidro PCNSrMg / 70 µm	-7,52000	9,76131	1,0000	-44,7338	29,6938
	Biovidro PCNSrMg / 100 µm	-17,60000	9,76131	0,9902	-54,8138	19,6138
	Sem tratamento / 20 µm	-26,12000	9,76131	0,6142	-63,3338	11,0938
	Sem tratamento / 45 µm	-29,04000	9,76131	0,3898	-66,2538	8,1738
	Sem tratamento / 70 µm	-30,86000	9,76131	0,2707	-68,0738	6,3538

	Sem tratamento / 100 µm	-34,60000	9,76131	0,1076	-71,8138	2,6138
Biovidro PCNSr / 100 µm	Água / 20 µm	96,02067*	9,76131	0,0000	58,8068	133,2345
	Água / 45 µm	89,14000*	9,76131	0,0000	51,9262	126,3538
	Água / 70 µm	90,83333*	9,76131	0,0000	53,6195	128,0472
	Água / 100 µm	79,23333*	9,76131	0,0000	42,0195	116,4472
	Elmex / 20 µm	,59000	9,76131	1,0000	-36,6238	37,8038
	Elmex / 45 µm	-3,80667	9,76131	1,0000	-41,0205	33,4072
	Elmex / 70 µm	-9,77333	9,76131	1,0000	-46,9872	27,4405
	Elmex / 100 µm	-19,56000	9,76131	0,9642	-56,7738	17,6538
	Biovidro 45S5 / 20 µm	-2,84000	9,76131	1,0000	-40,0538	34,3738
	Biovidro 45S5 / 45 µm	,02000	9,76131	1,0000	-37,1938	37,2338
	Biovidro 45S5 / 70 µm	-5,26000	9,76131	1,0000	-42,4738	31,9538
	Biovidro 45S5 / 100 µm	-10,15000	9,76131	1,0000	-47,3638	27,0638
	Biovidro PCNSr / 20 µm	4,64000	9,76131	1,0000	-32,5738	41,8538
	Biovidro PCNSr / 45 µm	-1,64000	9,76131	1,0000	-38,8538	35,5738
	Biovidro PCNSr / 70 µm	5,46000	9,76131	1,0000	-31,7538	42,6738
	Biovidro PCNSrTi / 20 µm	12,40000	9,76131	1,0000	-24,8138	49,6138
	Biovidro PCNSrTi / 45 µm	12,16000	9,76131	1,0000	-25,0538	49,3738
	Biovidro PCNSrTi / 70 µm	8,74000	9,76131	1,0000	-28,4738	45,9538
	Biovidro PCNSrTi / 100 µm	,86000	9,76131	1,0000	-36,3538	38,0738
	Biovidro PCNSrMg / 20 µm	9,10000	9,76131	1,0000	-28,1138	46,3138
	Biovidro PCNSrMg / 45 µm	15,84000	9,76131	0,9978	-21,3738	53,0538
	Biovidro PCNSrMg / 70 µm	-2,06000	9,76131	1,0000	-39,2738	35,1538
	Biovidro PCNSrMg / 100 µm	-12,14000	9,76131	1,0000	-49,3538	25,0738
	Sem tratamento / 20 µm	-20,66000	9,76131	0,9359	-57,8738	16,5538
	Sem tratamento / 45 µm	-23,58000	9,76131	0,7976	-60,7938	13,6338
	Sem tratamento / 70 µm	-25,40000	9,76131	0,6699	-62,6138	11,8138
	Sem tratamento / 100 µm	-29,14000	9,76131	0,3826	-66,3538	8,0738
Biovidro PCNSrTi / 20 µm	Água / 20 µm	83,62067*	9,76131	0,0000	46,4068	120,8345
	Água / 45 µm	76,74000*	9,76131	0,0000	39,5262	113,9538
	Água / 70 µm	78,43333*	9,76131	0,0000	41,2195	115,6472
	Água / 100 µm	66,83333*	9,76131	0,0000	29,6195	104,0472
	Elmex / 20 µm	-11,81000	9,76131	1,0000	-49,0238	25,4038

	Elmex / 45 µm	-16,20667	9,76131	0,9969	-53,4205	21,0072
	Elmex / 70 µm	-22,17333	9,76131	0,8760	-59,3872	15,0405
	Elmex / 100 µm	-31,96000	9,76131	0,2112	-69,1738	5,2538
	Biovidro 45S5 / 20 µm	-15,24000	9,76131	0,9988	-52,4538	21,9738
	Biovidro 45S5 / 45 µm	-12,38000	9,76131	1,0000	-49,5938	24,8338
	Biovidro 45S5 / 70 µm	-17,66000	9,76131	0,9897	-54,8738	19,5538
	Biovidro 45S5 / 100 µm	-22,55000	9,76131	0,8571	-59,7638	14,6638
	Biovidro PCNSr / 20 µm	-7,76000	9,76131	1,0000	-44,9738	29,4538
	Biovidro PCNSr / 45 µm	-14,04000	9,76131	0,9997	-51,2538	23,1738
	Biovidro PCNSr / 70 µm	-6,94000	9,76131	1,0000	-44,1538	30,2738
	Biovidro PCNSr / 100 µm	-12,40000	9,76131	1,0000	-49,6138	24,8138
	Biovidro PCNSrTi / 45 µm	-,24000	9,76131	1,0000	-37,4538	36,9738
	Biovidro PCNSrTi / 70 µm	-3,66000	9,76131	1,0000	-40,8738	33,5538
	Biovidro PCNSrTi / 100 µm	-11,54000	9,76131	1,0000	-48,7538	25,6738
	Biovidro PCNSrMg / 20 µm	-3,30000	9,76131	1,0000	-40,5138	33,9138
	Biovidro PCNSrMg / 45 µm	3,44000	9,76131	1,0000	-33,7738	40,6538
	Biovidro PCNSrMg / 70 µm	-14,46000	9,76131	0,9995	-51,6738	22,7538
	Biovidro PCNSrMg / 100 µm	-24,54000	9,76131	0,7332	-61,7538	12,6738
	Sem tratamento / 20 µm	-33,06000	9,76131	0,1616	-70,2738	4,1538
	Sem tratamento / 45 µm	-35,98000	9,76131	0,0726	-73,1938	1,2338
	Sem tratamento / 70 µm	-37,80000*	9,76131	0,0416	-75,0138	-,5862
	Sem tratamento / 100 µm	-41,54000*	9,76131	0,0117	-78,7538	-4,3262
Biovidro PCNSrTi / 45 µm	Água / 20 µm	83,86067*	9,76131	0,0000	46,6468	121,0745
	Água / 45 µm	76,98000*	9,76131	0,0000	39,7662	114,1938
	Água / 70 µm	78,67333*	9,76131	0,0000	41,4595	115,8872
	Água / 100 µm	67,07333*	9,76131	0,0000	29,8595	104,2872
	Elmex / 20 µm	-11,57000	9,76131	1,0000	-48,7838	25,6438
	Elmex / 45 µm	-15,96667	9,76131	0,9975	-53,1805	21,2472
	Elmex / 70 µm	-21,93333	9,76131	0,8873	-59,1472	15,2805
	Elmex / 100 µm	-31,72000	9,76131	0,2234	-68,9338	5,4938
	Biovidro 45S5 / 20 µm	-15,00000	9,76131	0,9991	-52,2138	22,2138
	Biovidro 45S5 / 45 µm	-12,14000	9,76131	1,0000	-49,3538	25,0738
	Biovidro 45S5 / 70 µm	-17,42000	9,76131	0,9914	-54,6338	19,7938

	Biovidro 45S5 / 100 µm	-22,31000	9,76131	0,8694	-59,5238	14,9038
	Biovidro PCNSr / 20 µm	-7,52000	9,76131	1,0000	-44,7338	29,6938
	Biovidro PCNSr / 45 µm	-13,80000	9,76131	0,9998	-51,0138	23,4138
	Biovidro PCNSr / 70 µm	-6,70000	9,76131	1,0000	-43,9138	30,5138
	Biovidro PCNSr / 100 µm	-12,16000	9,76131	1,0000	-49,3738	25,0538
	Biovidro PCNSrTi / 20 µm	,24000	9,76131	1,0000	-36,9738	37,4538
	Biovidro PCNSrTi / 70 µm	-3,42000	9,76131	1,0000	-40,6338	33,7938
	Biovidro PCNSrTi / 100 µm	-11,30000	9,76131	1,0000	-48,5138	25,9138
	Biovidro PCNSrMg / 20 µm	-3,06000	9,76131	1,0000	-40,2738	34,1538
	Biovidro PCNSrMg / 45 µm	3,68000	9,76131	1,0000	-33,5338	40,8938
	Biovidro PCNSrMg / 70 µm	-14,22000	9,76131	0,9996	-51,4338	22,9938
	Biovidro PCNSrMg / 100 µm	-24,30000	9,76131	0,7500	-61,5138	12,9138
	Sem tratamento / 20 µm	-32,82000	9,76131	0,1716	-70,0338	4,3938
	Sem tratamento / 45 µm	-35,74000	9,76131	0,0779	-72,9538	1,4738
	Sem tratamento / 70 µm	-37,56000*	9,76131	0,0449	-74,7738	-,3462
	Sem tratamento / 100 µm	-41,30000*	9,76131	0,0128	-78,5138	-4,0862
Biovidro PCNSrTi / 70 µm	Água / 20 µm	87,28067*	9,76131	0,0000	50,0668	124,4945
	Água / 45 µm	80,40000*	9,76131	0,0000	43,1862	117,6138
	Água / 70 µm	82,09333*	9,76131	0,0000	44,8795	119,3072
	Água / 100 µm	70,49333*	9,76131	0,0000	33,2795	107,7072
	Elmex / 20 µm	-8,15000	9,76131	1,0000	-45,3638	29,0638
	Elmex / 45 µm	-12,54667	9,76131	1,0000	-49,7605	24,6672
	Elmex / 70 µm	-18,51333	9,76131	0,9812	-55,7272	18,7005
	Elmex / 100 µm	-28,30000	9,76131	0,4442	-65,5138	8,9138
	Biovidro 45S5 / 20 µm	-11,58000	9,76131	1,0000	-48,7938	25,6338
	Biovidro 45S5 / 45 µm	-8,72000	9,76131	1,0000	-45,9338	28,4938
	Biovidro 45S5 / 70 µm	-14,00000	9,76131	0,9997	-51,2138	23,2138
	Biovidro 45S5 / 100 µm	-18,89000	9,76131	0,9760	-56,1038	18,3238
	Biovidro PCNSr / 20 µm	-4,10000	9,76131	1,0000	-41,3138	33,1138
	Biovidro PCNSr / 45 µm	-10,38000	9,76131	1,0000	-47,5938	26,8338
	Biovidro PCNSr / 70 µm	-3,28000	9,76131	1,0000	-40,4938	33,9338
	Biovidro PCNSr / 100 µm	-8,74000	9,76131	1,0000	-45,9538	28,4738
	Biovidro PCNSrTi / 20 µm	3,66000	9,76131	1,0000	-33,5538	40,8738

	Biovidro PCNSrTi / 45 µm	3,42000	9,76131	1,0000	-33,7938	40,6338
	Biovidro PCNSrTi / 100 µm	-7,88000	9,76131	1,0000	-45,0938	29,3338
	Biovidro PCNSrMg / 20 µm	,36000	9,76131	1,0000	-36,8538	37,5738
	Biovidro PCNSrMg / 45 µm	7,10000	9,76131	1,0000	-30,1138	44,3138
	Biovidro PCNSrMg / 70 µm	-10,80000	9,76131	1,0000	-48,0138	26,4138
	Biovidro PCNSrMg / 100 µm	-20,88000	9,76131	0,9288	-58,0938	16,3338
	Sem tratamento / 20 µm	-29,40000	9,76131	0,3644	-66,6138	7,8138
	Sem tratamento / 45 µm	-32,32000	9,76131	0,1939	-69,5338	4,8938
	Sem tratamento / 70 µm	-34,14000	9,76131	0,1219	-71,3538	3,0738
	Sem tratamento / 100 µm	-37,88000*	9,76131	0,0406	-75,0938	-,6662
Biovidro PCNSrTi / 100 µm	Água / 20 µm	95,16067*	9,76131	0,0000	57,9468	132,3745
	Água / 45 µm	88,28000*	9,76131	0,0000	51,0662	125,4938
	Água / 70 µm	89,97333*	9,76131	0,0000	52,7595	127,1872
	Água / 100 µm	78,37333*	9,76131	0,0000	41,1595	115,5872
	Elmex / 20 µm	-,27000	9,76131	1,0000	-37,4838	36,9438
	Elmex / 45 µm	-4,66667	9,76131	1,0000	-41,8805	32,5472
	Elmex / 70 µm	-10,63333	9,76131	1,0000	-47,8472	26,5805
	Elmex / 100 µm	-20,42000	9,76131	0,9431	-57,6338	16,7938
	Biovidro 45S5 / 20 µm	-3,70000	9,76131	1,0000	-40,9138	33,5138
	Biovidro 45S5 / 45 µm	-,84000	9,76131	1,0000	-38,0538	36,3738
	Biovidro 45S5 / 70 µm	-6,12000	9,76131	1,0000	-43,3338	31,0938
	Biovidro 45S5 / 100 µm	-11,01000	9,76131	1,0000	-48,2238	26,2038
	Biovidro PCNSr / 20 µm	3,78000	9,76131	1,0000	-33,4338	40,9938
	Biovidro PCNSr / 45 µm	-2,50000	9,76131	1,0000	-39,7138	34,7138
	Biovidro PCNSr / 70 µm	4,60000	9,76131	1,0000	-32,6138	41,8138
	Biovidro PCNSr / 100 µm	-,86000	9,76131	1,0000	-38,0738	36,3538
	Biovidro PCNSrTi / 20 µm	11,54000	9,76131	1,0000	-25,6738	48,7538
	Biovidro PCNSrTi / 45 µm	11,30000	9,76131	1,0000	-25,9138	48,5138
	Biovidro PCNSrTi / 70 µm	7,88000	9,76131	1,0000	-29,3338	45,0938
	Biovidro PCNSrMg / 20 µm	8,24000	9,76131	1,0000	-28,9738	45,4538
	Biovidro PCNSrMg / 45 µm	14,98000	9,76131	0,9991	-22,2338	52,1938
	Biovidro PCNSrMg / 70 µm	-2,92000	9,76131	1,0000	-40,1338	34,2938

	Biovidro PCNSrMg / 100 µm	-13,00000	9,76131	0,9999	-50,2138	24,2138
	Sem tratamento / 20 µm	-21,52000	9,76131	0,9050	-58,7338	15,6938
	Sem tratamento / 45 µm	-24,44000	9,76131	0,7402	-61,6538	12,7738
	Sem tratamento / 70 µm	-26,26000	9,76131	0,6033	-63,4738	10,9538
	Sem tratamento / 100 µm	-30,00000	9,76131	0,3240	-67,2138	7,2138
Biovidro PCNSrMg / 20 µm	Água / 20 µm	86,92067*	9,76131	0,0000	49,7068	124,1345
	Água / 45 µm	80,04000*	9,76131	0,0000	42,8262	117,2538
	Água / 70 µm	81,73333*	9,76131	0,0000	44,5195	118,9472
	Água / 100 µm	70,13333*	9,76131	0,0000	32,9195	107,3472
	Elmex / 20 µm	-8,51000	9,76131	1,0000	-45,7238	28,7038
	Elmex / 45 µm	-12,90667	9,76131	0,9999	-50,1205	24,3072
	Elmex / 70 µm	-18,87333	9,76131	0,9763	-56,0872	18,3405
	Elmex / 100 µm	-28,66000	9,76131	0,4174	-65,8738	8,5538
	Biovidro 45S5 / 20 µm	-11,94000	9,76131	1,0000	-49,1538	25,2738
	Biovidro 45S5 / 45 µm	-9,08000	9,76131	1,0000	-46,2938	28,1338
	Biovidro 45S5 / 70 µm	-14,36000	9,76131	0,9995	-51,5738	22,8538
	Biovidro 45S5 / 100 µm	-19,25000	9,76131	0,9701	-56,4638	17,9638
	Biovidro PCNSr / 20 µm	-4,46000	9,76131	1,0000	-41,6738	32,7538
	Biovidro PCNSr / 45 µm	-10,74000	9,76131	1,0000	-47,9538	26,4738
	Biovidro PCNSr / 70 µm	-3,64000	9,76131	1,0000	-40,8538	33,5738
	Biovidro PCNSr / 100 µm	-9,10000	9,76131	1,0000	-46,3138	28,1138
	Biovidro PCNSrTi / 20 µm	3,30000	9,76131	1,0000	-33,9138	40,5138
	Biovidro PCNSrTi / 45 µm	3,06000	9,76131	1,0000	-34,1538	40,2738
	Biovidro PCNSrTi / 70 µm	-,36000	9,76131	1,0000	-37,5738	36,8538
	Biovidro PCNSrTi / 100 µm	-8,24000	9,76131	1,0000	-45,4538	28,9738
	Biovidro PCNSrMg / 45 µm	6,74000	9,76131	1,0000	-30,4738	43,9538
	Biovidro PCNSrMg / 70 µm	-11,16000	9,76131	1,0000	-48,3738	26,0538
	Biovidro PCNSrMg / 100 µm	-21,24000	9,76131	0,9160	-58,4538	15,9738
	Sem tratamento / 20 µm	-29,76000	9,76131	0,3399	-66,9738	7,4538
	Sem tratamento / 45 µm	-32,68000	9,76131	0,1776	-69,8938	4,5338
	Sem tratamento / 70 µm	-34,50000	9,76131	0,1106	-71,7138	2,7138
	Sem tratamento / 100 µm	-38,24000*	9,76131	0,0361	-75,4538	-1,0262
Biovidro PCNSrMg / 45 µm	Água / 20 µm	80,18067*	9,76131	0,0000	42,9668	117,3945

	Água / 45 µm	73,30000*	9,76131	0,0000	36,0862	110,5138
	Água / 70 µm	74,99333*	9,76131	0,0000	37,7795	112,2072
	Água / 100 µm	63,39333*	9,76131	0,0000	26,1795	100,6072
	Elmex / 20 µm	-15,25000	9,76131	0,9988	-52,4638	21,9638
	Elmex / 45 µm	-19,64667	9,76131	0,9624	-56,8605	17,5672
	Elmex / 70 µm	-25,61333	9,76131	0,6536	-62,8272	11,6005
	Elmex / 100 µm	-35,40000	9,76131	0,0859	-72,6138	1,8138
	Biovidro 45S5 / 20 µm	-18,68000	9,76131	0,9790	-55,8938	18,5338
	Biovidro 45S5 / 45 µm	-15,82000	9,76131	0,9978	-53,0338	21,3938
	Biovidro 45S5 / 70 µm	-21,10000	9,76131	0,9211	-58,3138	16,1138
	Biovidro 45S5 / 100 µm	-25,99000	9,76131	0,6244	-63,2038	11,2238
	Biovidro PCNSr / 20 µm	-11,20000	9,76131	1,0000	-48,4138	26,0138
	Biovidro PCNSr / 45 µm	-17,48000	9,76131	0,9910	-54,6938	19,7338
	Biovidro PCNSr / 70 µm	-10,38000	9,76131	1,0000	-47,5938	26,8338
	Biovidro PCNSr / 100 µm	-15,84000	9,76131	0,9978	-53,0538	21,3738
	Biovidro PCNSrTi / 20 µm	-3,44000	9,76131	1,0000	-40,6538	33,7738
	Biovidro PCNSrTi / 45 µm	-3,68000	9,76131	1,0000	-40,8938	33,5338
	Biovidro PCNSrTi / 70 µm	-7,10000	9,76131	1,0000	-44,3138	30,1138
	Biovidro PCNSrTi / 100 µm	-14,98000	9,76131	0,9991	-52,1938	22,2338
	Biovidro PCNSrMg / 20 µm	-6,74000	9,76131	1,0000	-43,9538	30,4738
	Biovidro PCNSrMg / 70 µm	-17,90000	9,76131	0,9877	-55,1138	19,3138
	Biovidro PCNSrMg / 100 µm	-27,98000	9,76131	0,4685	-65,1938	9,2338
	Sem tratamento / 20 µm	-36,50000	9,76131	0,0622	-73,7138	,7138
	Sem tratamento / 45 µm	-39,42000*	9,76131	0,0245	-76,6338	-2,2062
	Sem tratamento / 70 µm	-41,24000*	9,76131	0,0131	-78,4538	-4,0262
	Sem tratamento / 100 µm	-44,98000*	9,76131	0,0032	-82,1938	-7,7662
Biovidro PCNSrMg / 70 µm	Água / 20 µm	98,08067*	9,76131	0,0000	60,8668	135,2945
	Água / 45 µm	91,20000*	9,76131	0,0000	53,9862	128,4138
	Água / 70 µm	92,89333*	9,76131	0,0000	55,6795	130,1072
	Água / 100 µm	81,29333*	9,76131	0,0000	44,0795	118,5072
	Elmex / 20 µm	2,65000	9,76131	1,0000	-34,5638	39,8638
	Elmex / 45 µm	-1,74667	9,76131	1,0000	-38,9605	35,4672
	Elmex / 70 µm	-7,71333	9,76131	1,0000	-44,9272	29,5005

	Elmex / 100 µm	-17,50000	9,76131	0,9909	-54,7138	19,7138
	Biovidro 45S5 / 20 µm	-,78000	9,76131	1,0000	-37,9938	36,4338
	Biovidro 45S5 / 45 µm	2,08000	9,76131	1,0000	-35,1338	39,2938
	Biovidro 45S5 / 70 µm	-3,20000	9,76131	1,0000	-40,4138	34,0138
	Biovidro 45S5 / 100 µm	-8,09000	9,76131	1,0000	-45,3038	29,1238
	Biovidro PCNSr / 20 µm	6,70000	9,76131	1,0000	-30,5138	43,9138
	Biovidro PCNSr / 45 µm	,42000	9,76131	1,0000	-36,7938	37,6338
	Biovidro PCNSr / 70 µm	7,52000	9,76131	1,0000	-29,6938	44,7338
	Biovidro PCNSr / 100 µm	2,06000	9,76131	1,0000	-35,1538	39,2738
	Biovidro PCNSrTi / 20 µm	14,46000	9,76131	0,9995	-22,7538	51,6738
	Biovidro PCNSrTi / 45 µm	14,22000	9,76131	0,9996	-22,9938	51,4338
	Biovidro PCNSrTi / 70 µm	10,80000	9,76131	1,0000	-26,4138	48,0138
	Biovidro PCNSrTi / 100 µm	2,92000	9,76131	1,0000	-34,2938	40,1338
	Biovidro PCNSrMg / 20 µm	11,16000	9,76131	1,0000	-26,0538	48,3738
	Biovidro PCNSrMg / 45 µm	17,90000	9,76131	0,9877	-19,3138	55,1138
	Biovidro PCNSrMg / 100 µm	-10,08000	9,76131	1,0000	-47,2938	27,1338
	Sem tratamento / 20 µm	-18,60000	9,76131	0,9801	-55,8138	18,6138
	Sem tratamento / 45 µm	-21,52000	9,76131	0,9050	-58,7338	15,6938
	Sem tratamento / 70 µm	-23,34000	9,76131	0,8125	-60,5538	13,8738
	Sem tratamento / 100 µm	-27,08000	9,76131	0,5386	-64,2938	10,1338
Biovidro PCNSrMg / 100 µm	Água / 20 µm	108,16067*	9,76131	0,0000	70,9468	145,3745
	Água / 45 µm	101,28000*	9,76131	0,0000	64,0662	138,4938
	Água / 70 µm	102,97333*	9,76131	0,0000	65,7595	140,1872
	Água / 100 µm	91,37333*	9,76131	0,0000	54,1595	128,5872
	Elmex / 20 µm	12,73000	9,76131	0,9999	-24,4838	49,9438
	Elmex / 45 µm	8,33333	9,76131	1,0000	-28,8805	45,5472
	Elmex / 70 µm	2,36667	9,76131	1,0000	-34,8472	39,5805
	Elmex / 100 µm	-7,42000	9,76131	1,0000	-44,6338	29,7938
	Biovidro 45S5 / 20 µm	9,30000	9,76131	1,0000	-27,9138	46,5138
	Biovidro 45S5 / 45 µm	12,16000	9,76131	1,0000	-25,0538	49,3738
	Biovidro 45S5 / 70 µm	6,88000	9,76131	1,0000	-30,3338	44,0938
	Biovidro 45S5 / 100 µm	1,99000	9,76131	1,0000	-35,2238	39,2038
	Biovidro PCNSr / 20 µm	16,78000	9,76131	0,9949	-20,4338	53,9938

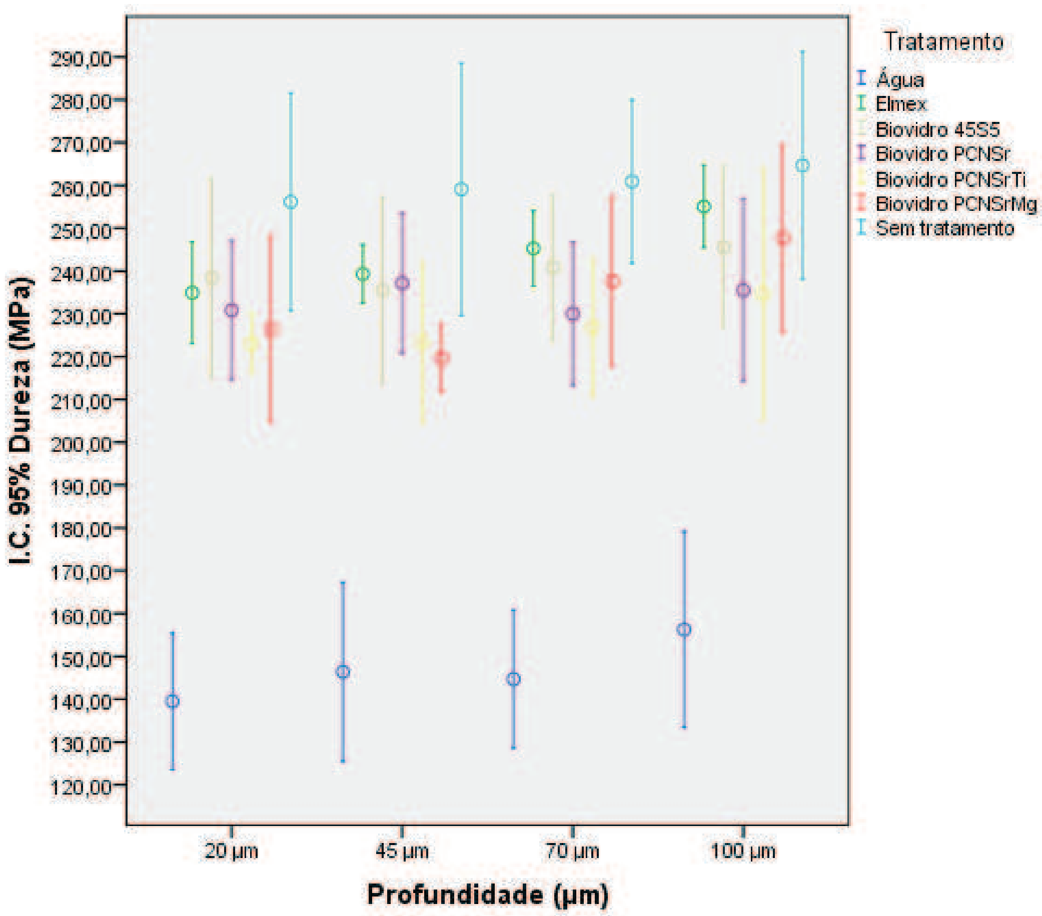
	Biovidro PCNSr / 45 µm	10,50000	9,76131	1,0000	-26,7138	47,7138
	Biovidro PCNSr / 70 µm	17,60000	9,76131	0,9902	-19,6138	54,8138
	Biovidro PCNSr / 100 µm	12,14000	9,76131	1,0000	-25,0738	49,3538
	Biovidro PCNSrTi / 20 µm	24,54000	9,76131	0,7332	-12,6738	61,7538
	Biovidro PCNSrTi / 45 µm	24,30000	9,76131	0,7500	-12,9138	61,5138
	Biovidro PCNSrTi / 70 µm	20,88000	9,76131	0,9288	-16,3338	58,0938
	Biovidro PCNSrTi / 100 µm	13,00000	9,76131	0,9999	-24,2138	50,2138
	Biovidro PCNSrMg / 20 µm	21,24000	9,76131	0,9160	-15,9738	58,4538
	Biovidro PCNSrMg / 45 µm	27,98000	9,76131	0,4685	-9,2338	65,1938
	Biovidro PCNSrMg / 70 µm	10,08000	9,76131	1,0000	-27,1338	47,2938
	Sem tratamento / 20 µm	-8,52000	9,76131	1,0000	-45,7338	28,6938
	Sem tratamento / 45 µm	-11,44000	9,76131	1,0000	-48,6538	25,7738
	Sem tratamento / 70 µm	-13,26000	9,76131	0,9999	-50,4738	23,9538
	Sem tratamento / 100 µm	-17,00000	9,76131	0,9939	-54,2138	20,2138
Sem tratamento / 20 µm	Água / 20 µm	116,68067*	9,76131	0,0000	79,4668	153,8945
	Água / 45 µm	109,80000*	9,76131	0,0000	72,5862	147,0138
	Água / 70 µm	111,49333*	9,76131	0,0000	74,2795	148,7072
	Água / 100 µm	99,89333*	9,76131	0,0000	62,6795	137,1072
	Elmex / 20 µm	21,25000	9,76131	0,9156	-15,9638	58,4638
	Elmex / 45 µm	16,85333	9,76131	0,9946	-20,3605	54,0672
	Elmex / 70 µm	10,88667	9,76131	1,0000	-26,3272	48,1005
	Elmex / 100 µm	1,10000	9,76131	1,0000	-36,1138	38,3138
	Biovidro 45S5 / 20 µm	17,82000	9,76131	0,9884	-19,3938	55,0338
	Biovidro 45S5 / 45 µm	20,68000	9,76131	0,9353	-16,5338	57,8938
	Biovidro 45S5 / 70 µm	15,40000	9,76131	0,9986	-21,8138	52,6138
	Biovidro 45S5 / 100 µm	10,51000	9,76131	1,0000	-26,7038	47,7238
	Biovidro PCNSr / 20 µm	25,30000	9,76131	0,6774	-11,9138	62,5138
	Biovidro PCNSr / 45 µm	19,02000	9,76131	0,9740	-18,1938	56,2338
	Biovidro PCNSr / 70 µm	26,12000	9,76131	0,6142	-11,0938	63,3338
	Biovidro PCNSr / 100 µm	20,66000	9,76131	0,9359	-16,5538	57,8738
	Biovidro PCNSrTi / 20 µm	33,06000	9,76131	0,1616	-4,1538	70,2738
	Biovidro PCNSrTi / 45 µm	32,82000	9,76131	0,1716	-4,3938	70,0338

	Biovidro PCNSrTi / 70 µm	29,40000	9,76131	0,3644	-7,8138	66,6138
	Biovidro PCNSrTi / 100 µm	21,52000	9,76131	0,9050	-15,6938	58,7338
	Biovidro PCNSrMg / 20 µm	29,76000	9,76131	0,3399	-7,4538	66,9738
	Biovidro PCNSrMg / 45 µm	36,50000	9,76131	0,0622	-,7138	73,7138
	Biovidro PCNSrMg / 70 µm	18,60000	9,76131	0,9801	-18,6138	55,8138
	Biovidro PCNSrMg / 100 µm	8,52000	9,76131	1,0000	-28,6938	45,7338
	Sem tratamento / 45 µm	-2,92000	9,76131	1,0000	-40,1338	34,2938
	Sem tratamento / 70 µm	-4,74000	9,76131	1,0000	-41,9538	32,4738
	Sem tratamento / 100 µm	-8,48000	9,76131	1,0000	-45,6938	28,7338
Sem tratamento / 45 µm	Água / 20 µm	119,60067*	9,76131	0,0000	82,3868	156,8145
	Água / 45 µm	112,72000*	9,76131	0,0000	75,5062	149,9338
	Água / 70 µm	114,41333*	9,76131	0,0000	77,1995	151,6272
	Água / 100 µm	102,81333*	9,76131	0,0000	65,5995	140,0272
	Elmex / 20 µm	24,17000	9,76131	0,7589	-13,0438	61,3838
	Elmex / 45 µm	19,77333	9,76131	0,9596	-17,4405	56,9872
	Elmex / 70 µm	13,80667	9,76131	0,9998	-23,4072	51,0205
	Elmex / 100 µm	4,02000	9,76131	1,0000	-33,1938	41,2338
	Biovidro 45S5 / 20 µm	20,74000	9,76131	0,9334	-16,4738	57,9538
	Biovidro 45S5 / 45 µm	23,60000	9,76131	0,7964	-13,6138	60,8138
	Biovidro 45S5 / 70 µm	18,32000	9,76131	0,9835	-18,8938	55,5338
	Biovidro 45S5 / 100 µm	13,43000	9,76131	0,9999	-23,7838	50,6438
	Biovidro PCNSr / 20 µm	28,22000	9,76131	0,4502	-8,9938	65,4338
	Biovidro PCNSr / 45 µm	21,94000	9,76131	0,8870	-15,2738	59,1538
	Biovidro PCNSr / 70 µm	29,04000	9,76131	0,3898	-8,1738	66,2538
	Biovidro PCNSr / 100 µm	23,58000	9,76131	0,7976	-13,6338	60,7938
	Biovidro PCNSrTi / 20 µm	35,98000	9,76131	0,0726	-1,2338	73,1938
	Biovidro PCNSrTi / 45 µm	35,74000	9,76131	0,0779	-1,4738	72,9538
	Biovidro PCNSrTi / 70 µm	32,32000	9,76131	0,1939	-4,8938	69,5338
	Biovidro PCNSrTi / 100 µm	24,44000	9,76131	0,7402	-12,7738	61,6538
	Biovidro PCNSrMg / 20 µm	32,68000	9,76131	0,1776	-4,5338	69,8938
	Biovidro PCNSrMg / 45 µm	39,42000*	9,76131	0,0245	2,2062	76,6338
	Biovidro PCNSrMg / 70 µm	21,52000	9,76131	0,9050	-15,6938	58,7338

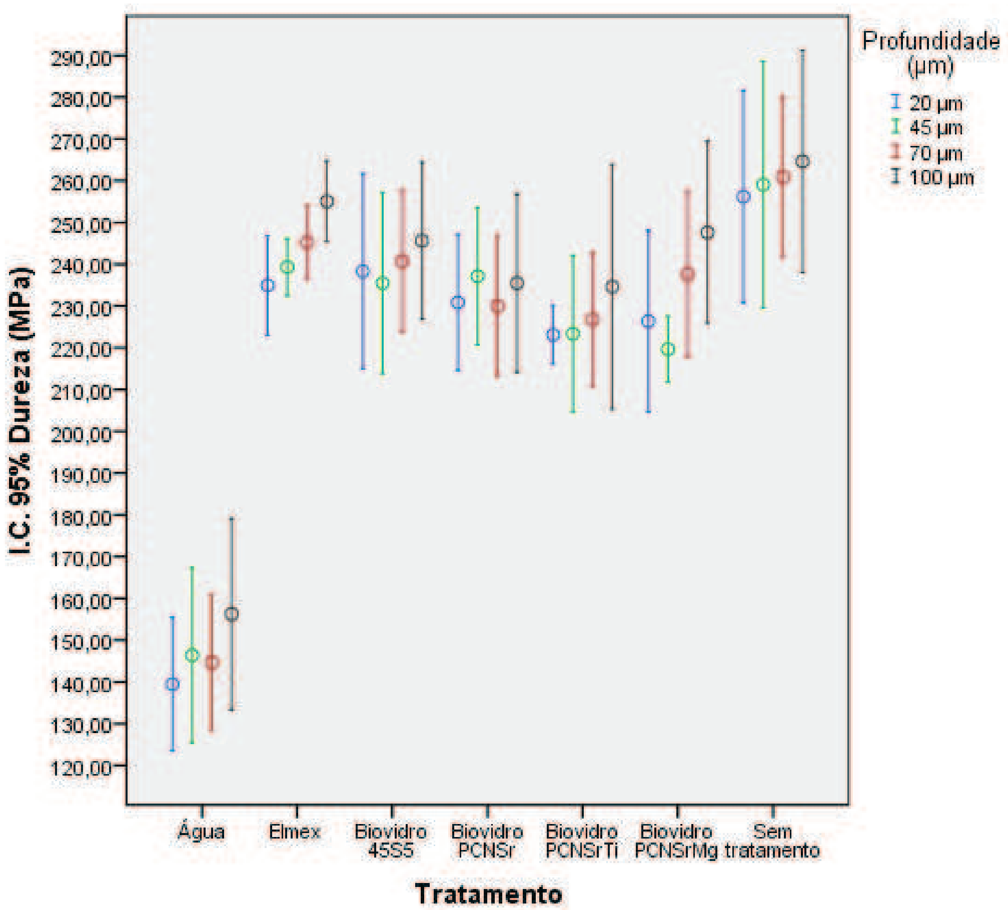
	Biovidro PCNSrMg / 100 µm	11,44000	9,76131	1,0000	-25,7738	48,6538
	Sem tratamento / 20 µm	2,92000	9,76131	1,0000	-34,2938	40,1338
	Sem tratamento / 70 µm	-1,82000	9,76131	1,0000	-39,0338	35,3938
	Sem tratamento / 100 µm	-5,56000	9,76131	1,0000	-42,7738	31,6538
Sem tratamento / 70 µm	Água / 20 µm	121,42067*	9,76131	0,0000	84,2068	158,6345
	Água / 45 µm	114,54000*	9,76131	0,0000	77,3262	151,7538
	Água / 70 µm	116,23333*	9,76131	0,0000	79,0195	153,4472
	Água / 100 µm	104,63333*	9,76131	0,0000	67,4195	141,8472
	Elmex / 20 µm	25,99000	9,76131	0,6244	-11,2238	63,2038
	Elmex / 45 µm	21,59333	9,76131	0,9020	-15,6205	58,8072
	Elmex / 70 µm	15,62667	9,76131	0,9982	-21,5872	52,8405
	Elmex / 100 µm	5,84000	9,76131	1,0000	-31,3738	43,0538
	Biovidro 45S5 / 20 µm	22,56000	9,76131	0,8566	-14,6538	59,7738
	Biovidro 45S5 / 45 µm	25,42000	9,76131	0,6683	-11,7938	62,6338
	Biovidro 45S5 / 70 µm	20,14000	9,76131	0,9508	-17,0738	57,3538
	Biovidro 45S5 / 100 µm	15,25000	9,76131	0,9988	-21,9638	52,4638
	Biovidro PCNSr / 20 µm	30,04000	9,76131	0,3214	-7,1738	67,2538
	Biovidro PCNSr / 45 µm	23,76000	9,76131	0,7862	-13,4538	60,9738
	Biovidro PCNSr / 70 µm	30,86000	9,76131	0,2707	-6,3538	68,0738
	Biovidro PCNSr / 100 µm	25,40000	9,76131	0,6699	-11,8138	62,6138
	Biovidro PCNSrTi / 20 µm	37,80000*	9,76131	0,0416	,5862	75,0138
	Biovidro PCNSrTi / 45 µm	37,56000*	9,76131	0,0449	,3462	74,7738
	Biovidro PCNSrTi / 70 µm	34,14000	9,76131	0,1219	-3,0738	71,3538
	Biovidro PCNSrTi / 100 µm	26,26000	9,76131	0,6033	-10,9538	63,4738
	Biovidro PCNSrMg / 20 µm	34,50000	9,76131	0,1106	-2,7138	71,7138
	Biovidro PCNSrMg / 45 µm	41,24000*	9,76131	0,0131	4,0262	78,4538
	Biovidro PCNSrMg / 70 µm	23,34000	9,76131	0,8125	-13,8738	60,5538
	Biovidro PCNSrMg / 100 µm	13,26000	9,76131	0,9999	-23,9538	50,4738
	Sem tratamento / 20 µm	4,74000	9,76131	1,0000	-32,4738	41,9538
	Sem tratamento / 45 µm	1,82000	9,76131	1,0000	-35,3938	39,0338
	Sem tratamento / 100 µm	-3,74000	9,76131	1,0000	-40,9538	33,4738
Sem tratamento / 100 µm	Água / 20 µm	125,16067*	9,76131	0,0000	87,9468	162,3745
	Água / 45 µm	118,28000*	9,76131		81,0662	155,4938

				0,0000		
	Água / 70 µm	119,97333*	9,76131	0,0000	82,7595	157,1872
	Água / 100 µm	108,37333*	9,76131	0,0000	71,1595	145,5872
	Elmex / 20 µm	29,73000	9,76131	0,3419	-7,4838	66,9438
	Elmex / 45 µm	25,33333	9,76131	0,6749	-11,8805	62,5472
	Elmex / 70 µm	19,36667	9,76131	0,9680	-17,8472	56,5805
	Elmex / 100 µm	9,58000	9,76131	1,0000	-27,6338	46,7938
	Biovidro 45S5 / 20 µm	26,30000	9,76131	0,6001	-10,9138	63,5138
	Biovidro 45S5 / 45 µm	29,16000	9,76131	0,3812	-8,0538	66,3738
	Biovidro 45S5 / 70 µm	23,88000	9,76131	0,7783	-13,3338	61,0938
	Biovidro 45S5 / 100 µm	18,99000	9,76131	0,9745	-18,2238	56,2038
	Biovidro PCNSr / 20 µm	33,78000	9,76131	0,1342	-3,4338	70,9938
	Biovidro PCNSr / 45 µm	27,50000	9,76131	0,5057	-9,7138	64,7138
	Biovidro PCNSr / 70 µm	34,60000	9,76131	0,1076	-2,6138	71,8138
	Biovidro PCNSr / 100 µm	29,14000	9,76131	0,3826	-8,0738	66,3538
	Biovidro PCNSrTi / 20 µm	41,54000*	9,76131	0,0117	4,3262	78,7538
	Biovidro PCNSrTi / 45 µm	41,30000*	9,76131	0,0128	4,0862	78,5138
	Biovidro PCNSrTi / 70 µm	37,88000*	9,76131	0,0406	,6662	75,0938
	Biovidro PCNSrTi / 100 µm	30,00000	9,76131	0,3240	-7,2138	67,2138
	Biovidro PCNSrMg / 20 µm	38,24000*	9,76131	0,0361	1,0262	75,4538
	Biovidro PCNSrMg / 45 µm	44,98000*	9,76131	0,0032	7,7662	82,1938
	Biovidro PCNSrMg / 70 µm	27,08000	9,76131	0,5386	-10,1338	64,2938
	Biovidro PCNSrMg / 100 µm	17,00000	9,76131	0,9939	-20,2138	54,2138
	Sem tratamento / 20 µm	8,48000	9,76131	1,0000	-28,7338	45,6938
	Sem tratamento / 45 µm	5,56000	9,76131	1,0000	-31,6538	42,7738
	Sem tratamento / 70 µm	3,74000	9,76131	1,0000	-33,4738	40,9538

*. The mean difference is significant at the 0.05 level.


Tratamento
Água
Elmex
Biovidro 45S5
Biovidro PCNSr
Biovidro PCNSrTi
Biovidro PCNSrMg
Sem tratamento
I.C. 95% Dureza (MPa)
290,00
280,00
270,00
260,00
250,00
240,00
230,00
220,00
210,00
200,00
190,00
180,00
170,00
160,00
150,00
140,00
130,00
120,00
20 µm
45 µm
70 µm
100 µm
Profundidade (µm)

1


Profundidade (µm)
20 µm
45 µm
70 µm
100 µm
I.C. 95% Dureza (MPa)
290,00
280,00
270,00
260,00
250,00
240,00
230,00
220,00
210,00
200,00
190,00
180,00
170,00
160,00
150,00
140,00
130,00
120,00
Água
Elmex
Biovidro 45S5
Biovidro PCNSr
Biovidro PCNSrTi
Biovidro PCNSrMg
Sem tratamento
Tratamento

2