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Propriedades mecânicas e químicas de resinas compostas fluidas com diferentes estratégias adesivas

Governador Valadares
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Trabalho de conclusão de curso apresentado ao Departamento de Odontologia, do Instituto de Ciências da Vida, da Universidade Federal de Juiz de Fora, Campus Governador Valadares, como requisito parcial à obtenção do grau de bacharel em Odontologia.

Orientador: Prof. Dr. Rodrigo Varella de Carvalho

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RESUMO

As resinas compostas fluidas são amplamente utilizadas na odontologia restauradora, sendo que recentemente foram introduzidas as resinas autoadesivas, que dispensam o uso de sistemas adesivos separados. Este estudo comparou o grau de conversão e a microdureza superficial de uma resina composta fluida convencional (YFlow) e uma autoadesiva (YFlow SA), ambas da marca Yller. Foram confeccionados corpos de prova (n = 5 por grupo) com dimensões padronizadas (5 mm de diâmetro e 2 mm de espessura). O grau de conversão foi avaliado por espectroscopia FTIR, analisando a intensidade da banda de absorção em 1636 cm^{-1} antes e após a polimerização. A microdureza foi medida utilizando um microdurômetro Vickers com carga de 50 g por 45 segundos. Os dados foram analisados estatisticamente com teste t de Student (α=0,05). Os resultados demonstraram que a resina autoadesiva apresentou valores significativamente superior tanto no grau de conversão (73,6% ± 2,8) quanto na microdureza (39,9 HV ± 1,9) em comparação à resina convencional (56,2% ± 4,6 e 36,7 HV ± 2,2, respectivamente), com $p<0,05$ para ambas as comparações. Com base nas limitações desse estudo, é possível concluir que a resina fluida autoadesiva apresentou melhor desempenho nas propriedades avaliadas. Diferenças na sua composição química provavelmente são as responsáveis por esses resultados. No entanto, estudos adicionais são necessários para avaliar outras propriedades desses materiais, assim como estudos clínicos são necessários para a avaliação do desempenho dessas resinas em condições clínicas.

Palavras-chave: Dureza; Espectroscopia de Infravermelho com Transformada de Fourier; Polimerização; Resinas Compostas; Testes Mecânicos.

ABSTRACT

Flowable composite resins are widely used in restorative dentistry, and more recently, self-adhesive flowable composites have been introduced, eliminating the need for separate adhesive systems. This study compared the degree of conversion and surface microhardness of a conventional flowable composite (YFlow) and a self-adhesive flowable composite (YFlow SA), both from the YIler brand. Specimens (n = 5 per group) were fabricated with standardized dimensions (5 mm in diameter and 2 mm in thickness). The degree of conversion was evaluated using FTIR spectroscopy, analyzing the absorption band intensity at 1636 cm^{-1} before and after polymerization. Microhardness was measured using a Vickers microhardness tester with a 50 g load for 45 seconds. Data were statistically analyzed using Student's t-test ($\alpha = 0.05$). The results showed that the self-adhesive resin had significantly higher values in both degree of conversion (73.6% ± 2.8) and microhardness (39.9 HV ± 1.9) compared to the conventional resin (56.2% ± 4.6 and 36.7 HV ± 2.2, respectively), with $p < 0.05$ for both comparisons. Within the limitations of this study, it can be concluded that the self-adhesive flowable resin performed better in the evaluated properties. Differences in its chemical composition are likely responsible for these results. However, further studies are needed to assess other material properties as well as clinical studies to evaluate the performance of these resins under real clinical conditions.

Keywords: Composite Resins; Fourier Transform Infrared Spectroscopy; Hardness; Mechanical Tests; Polymerization.

SUMÁRIO

1 INTRODUÇÃO

A tecnologia hoje é uma grande aliada da odontologia, gerando avanços nos materiais odontológicos. As resinas compostas surgiram como uma solução inovadora, proporcionando estética e fixação, possibilitando desde restaurações mais simples até as mais complexas (MEIRELES, M. R. *et al.,* 2020). Resinas compostas odontológicas geralmente têm uma composição básica similar, constituída por uma fase orgânica à base de monômeros metacrilatos, uma fase inorgânica composta por partículas de sílica e vidro, um sistema iniciador e um agente de silanização (GERMAN, 2022). As propriedades reológicas das resinas compostas são determinadas pelas características dos monômeros metacrilatos usados na formulação, assim como pela quantidade de fase inorgânica da resina. Dessa forma, uma classificação utilizada para diferenciar as resinas compostas leva em consideração a viscosidade do material, classificando-as como: fluidas (*flowable)*, regulares e de alta viscosidade (*packable)* (BOMPOLAKI; LUBISICH; FUGOLIN, 2022).

Apesar de diversas melhorias nas propriedades físico-químicas dos compósitos restauradores e dos sistemas adesivos, a integridade entre dente e restauração pode apresentar lacunas (*gaps*) (JANG; PARK; HWANG, 2015). Essa interface, geralmente, está associada à hipersensibilidade pós-operatória, à descoloração marginal e à cárie secundária, o que pode comprometer a longevidade do elemento restaurado (VAIDYANATHAN T.; VAIDYANATHAN J., 2009). Do ponto de vista clínico, a simplificação de um procedimento o torna menos propenso a erros assim, reduzindo a sensibilidade da técnica, diminuindo a formação de *gaps* e facilitando a inserção do material na cavidade preparada (NAKANO EL, *et al.,* 2020).

Os compósitos fluidos convencionais apresentam maior fluidez, pois contêm uma menor quantidade de carga inorgânica e monômeros de baixa viscosidade, o que resulta em propriedades mecânicas de resistência inferiores quando comparados a outros compósitos, fato atribuído ao menor teor de carga (LABELLA R. *et al.,*1999). Essa característica direcionou seu uso clínico como base para materiais restauradores de alta viscosidade em restaurações de classes I, III e V, além de atuarem como selantes de fissuras e fossas (DAVID *et al.,* 2021; ZANATTA *et al.,* 2022).

As resinas autoadesivas também apresentam essas características, pois são formadas pela combinação de dois grupos funcionais: o sistema adesivo de passo

único (*all-in-one*) e resina composta fluida (VICHI A *et al.,* 2013). O monômero presente na resina fluida autoadesiva exibe propriedades ácidas, condiciona a estrutura do dente, une-se ao cálcio da estrutura dentária e possui dois grupos funcionais de metacrilato, que podem copolimerizar com outros monômeros de metacrilato (ZANATTA *et al.,* 2022).

A resistência ao desgaste é uma das propriedades ideais que o material restaurador deve apresentar, sendo desejável que ela se assemelhe à resistência do tecido dentário. O desgaste é definido como a perda de material causada pela interação mecânica da superfície com outro material que apresenta partículas mais duras. Na odontologia, o desgaste ocorre em função do contato funcional, da mastigação e do atrito exagerado das cerdas da escova durante a escovação (MAIR *et al.,* 1996). Estudos demonstraram que os compósitos fluidos possuem maior resistência ao desgaste do que os compósitos nanohíbridos convencionais (SUMINO *et al.,* 2013).

Portanto, o objetivo do presente estudo foi comparar o grau de conversão de monômeros em polímeros a microdureza superficial de uma resina composta fluida convencional com uma resina autoadesiva. A hipótese nula (H_0) assumida foi a de que não existem diferenças estatisticamente significativas entre os materiais em relação a essas variáveis.

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Propriedades mecânicas e químicas de resinas compostas fluidas com diferentes estratégias adesivas

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RESUMO

As resinas compostas fluidas são amplamente utilizadas na odontologia restauradora, sendo que recentemente foram introduzidas as resinas autoadesivas, que dispensam o uso de sistemas adesivos separados. Este estudo comparou o grau de conversão e a microdureza superficial de uma resina composta fluida convencional (YFlow) e uma autoadesiva (YFlow SA), ambas da marca Yller. Foram confeccionados corpos de prova (n = 5 por grupo) com dimensões padronizadas (5 mm de diâmetro e 2 mm de espessura). O grau de conversão foi avaliado por espectroscopia FTIR, analisando a intensidade da banda de absorção em 1636 cm^{-1} antes e após a polimerização. A microdureza foi medida utilizando um microdurômetro Vickers com carga de 50 g por 45 segundos. Os dados foram analisados estatisticamente com teste t de Student (α=0,05). Os resultados demonstraram que a resina autoadesiva apresentou valores significativamente superior tanto no grau de conversão (73,6% ± 2,8) quanto na microdureza (39,9 HV ± 1,9) em comparação à resina convencional (56,2% ± 4,6 e 36,7 HV ± 2,2, respectivamente), com $p<0,05$ para ambas as comparações. Com base nas limitações desse estudo, é possível concluir que a resina fluida autoadesiva apresentou melhor desempenho nas propriedades avaliadas. Diferenças na sua composição química provavelmente são as responsáveis por esses resultados. No entanto, estudos adicionais são necessários para avaliar outras propriedades desses materiais, assim como estudos clínicos são necessários para a avaliação do desempenho dessas resinas em condições clínicas.

Palavras-chave: Dureza; Espectroscopia de Infravermelho com Transformada de Fourier; Polimerização; Resinas Compostas; Testes Mecânicos.

INTRODUÇÃO

A tecnologia hoje é uma grande aliada da odontologia, gerando avanços nos materiais odontológicos. As resinas compostas surgiram como uma solução inovadora, proporcionando estética e fixação, possibilitando desde restaurações mais simples até as mais complexas. [1] Resinas compostas odontológicas geralmente têm uma composição básica similar, constituída por uma fase orgânica à base de monômeros metacrilatos, uma fase inorgânica composta por partículas de sílica e vidro, um sistema iniciador e um agente de silanização.[2] As propriedades reológicas das resinas compostas são determinadas pelas características dos monômeros metacrilatos usados na formulação, assim como pela quantidade de fase inorgânica da resina. Dessa forma, uma classificação utilizada para diferenciar as resinas compostas leva em consideração a viscosidade do material, classificando-as como: fluidas (*flowable)*, regulares e de alta viscosidade (*packable).*[3]

Apesar de diversas melhorias nas propriedades físico-químicas dos compósitos restauradores e dos sistemas adesivos, a integridade entre dente e restauração pode apresentar lacunas (*gaps*).[4] Essa interface, geralmente, está associada à hipersensibilidade pós-operatória, à descoloração marginal e à cárie secundária, o que pode comprometer a longevidade do elemento restaurado.[5] Do ponto de vista clínico, a simplificação de um procedimento o torna menos propenso a erros assim, reduzindo a sensibilidade da técnica, diminuindo a formação de *gaps* e facilitando a inserção do material na cavidade preparada.[6]

Os compósitos fluidos convencionais apresentam maior fluidez, pois contêm uma menor quantidade de carga inorgânica e monômeros de baixa viscosidade, o que resulta em propriedades mecânicas de resistência inferiores quando comparados a outros compósitos, fato atribuído ao menor teor de carga.[7] Essa característica direcionou seu uso clínico como base para materiais restauradores de alta viscosidade em restaurações de classes I, III e V, além de atuarem como selantes de fissuras e fossas. [8,9] Recentemente as resinas fluidas autoadesivas foram desenvolvidas, elas combinam a estratégia de adesão de um sistema adesivo de passo único (*all-in-one*), adicionando seus componentes a uma resina fluida convencional. Dessa forma, a necessidade de aplicação de um sistema adesivo de forma separada é eliminada.[10] O monômero presente na resina fluida autoadesiva exibe propriedades ácidas, condiciona a estrutura do dente, une-se ao cálcio da estrutura dentária e possui dois

grupos funcionais de metacrilato, que podem copolimerizar com outros monômeros de metacrilato.[11]

A resistência ao desgaste é uma das propriedades ideais que o material restaurador deve apresentar, sendo desejável que ela se assemelhe à resistência do tecido dentário. O desgaste é definido como a perda de material causada pela interação mecânica da superfície com outro material que apresenta partículas mais duras. Na odontologia, o desgaste ocorre em função do contato funcional, da mastigação e do atrito exagerado das cerdas da escova durante a escovação.[13] Estudos demonstraram que os compósitos fluidos possuem maior resistência ao desgaste do que os compósitos nanohíbridos convencionais.[12]

Portanto, o objetivo do presente estudo foi comparar o grau de conversão de monômeros em polímeros e a microdureza superficial de uma resina composta fluida convencional com uma resina autoadesiva. A hipótese nula (H_0) assumida foi a de que não existem diferenças estatisticamente significativas entre os materiais em relação a essas variáveis.

MATERIAIS E MÉTODOS

Foi conduzido um estudo *in vitro* de natureza quantitativa experimental. Os fatores avaliados foram as resinas compostas fluidas em dois níveis (convencional e autoadesiva). As variáveis de desfecho examinadas incluíram o grau de conversão de monômeros em polímeros e a microdureza Vickers. Na Tabela 1 estão descritos os grupos avaliados neste estudo.

Tabela 1. Descrição dos grupos avaliados.

Grupo	Resina	Composição	Fabricante	Lote	Cor
YF	Yflow (fluida convencional)	Monômeros metacrilatos; carga inorgânica; pigmentos; iniciadores e estabilizadores.	Yller	00016153	A2
YFSA	Yflow SA (fluida autoadesiva)	Monômero metacrilato; monômeros ácidos; cargas inorgânicas; pigmento; iniciadores e estabilizadores.	Yller	00013698	A2

*Composição informada pelo fabricante.

Fonte: Elaborado pelos autores.

Avaliação do grau de conversão (C=C)

O grau de conversão das resinas compostas foi avaliado utilizando a espectroscopia de infravermelho por transformada de Fourier (FTIR) com um espectrômetro Spectrum Two™ da PerkinElmer, equipado com um dispositivo de reflectância total atenuada (ATR), composto por um cristal horizontal de seleneto de zinco (ZnSe), com espelhos de angulação de 45º (PIKE Technologies, WI, USA). Um suporte foi acoplado para a fixação da unidade fotoativadora ao espectrofotômetro, permitindo a padronização de uma distância de 2 mm entre a extremidade da ponteira do LED e a amostra. Cada amostra foi depositada diretamente no cristal de ZnSe em um pequeno incremento e fotoativada por 20 segundos, utilizando um diodo emissor de luz (LED RADII; SDI, Bayswater, Austrália, 1.100 mW/cm² e comprimento de onda entre 440 e 480 nm). O software Spectrum Touch™ (PerkinElmer, Waltham, MA, EUA) foi utilizado no modo de varredura de monitoramento, empregando a apodização Happ-Genzel, com um intervalo de 1750–1550 cm^{-1}, resolução de 4 cm^{-1} e velocidade do espelho de 2,8 mm/s, em temperatura ambiente controlada de 23 °C (± 2 °C) e umidade relativa de 60% (± 5%). O grau de conversão para as resinas compostas fluidas, foi calculado considerando a intensidade da vibração do tipo estiramento da dupla ligação carbono-carbono na frequência de 1636 cm^{-1}. O estiramento simétrico do anel aromático em 1600 cm^{-1} das amostras polimerizadas e não polimerizadas foi utilizado como padrão interno.

Microdureza Vickers

Para o ensaio de microdureza Vickers foram confeccionados cinco (05) corpos de prova por grupo experimental, com formato cilíndrico de 5 mm de diâmetro e 2 mm de espessura. Os corpos de prova foram fotoativados por 20 segundos, no topo e na base, utilizando um diodo emissor de luz (LED RADII; SDI, Bayswater, Austrália, 1.100 mW/cm² e comprimento de onda entre 440 e 480 nm). O polimento da superfície foi realizado com lixas d´água com granulação de 400, 600, 1200 e 2000 em sequência, e em seguida foi realizado polimento com disco de feltro e pasta diamantada. Para a avaliação da microdureza superficial foram realizadas 3 indentações em cada amostra, aplicando-se uma carga de 50 gramas durante 45 segundos. Os valores de microdureza foram calculados de acordo com a equação $VH = P/2d^2$, onde P é a carga

em Newtons e d é a média dos valores das diagonais em um microdurômetro (Shimadzu modelo HMV-G 20DT, Shimadzu Corporation, Tóquio, Japão).

Análise estatística

A análise estatística foi realizada utilizando o software JASP (Version 0.18.3, Computer software, University of Amsterdam, Netherlands). Inicialmente, a normalidade e igualdade de variância dos dados foram avaliadas pelo teste de Shapiro-Wilk e Levene, respectivamente. Como a suposição de normalidade e igualdade de variância foram atendidas, os dados foram comparados entre os dois grupos (resina fluida convencional e resina fluida autoadesiva) por meio do teste t de Student para amostras independentes, com nível de significância estabelecido em 5% ($\alpha = 0,05$). Os resultados foram expressos como média (%) e desvio padrão para grau de conversão e média (HV) e desvio padrão para microdureza.

RESULTADOS

Conforme demonstrado na Tabela 2, a resina fluida autoadesiva apresentou desempenho superior ao da resina fluida convencional, tanto no grau de conversão de monômeros em polímeros (valor de $p < 0,001$), quanto na dureza superficial (valor de $p < 0,04$).

Tabela 2 – Média e desvio-padrão do grau de conversão (%) e microdureza superficial (MV) das resinas fluidas avaliadas.

Resinas compostas fluidas	Grau de conversão	Microdureza superficial
Resina convencional YFlow (YF)	56,2 (± 4,6) ^{B}	36,7 (± 2,2) ^{B}
Resina autoadesiva YFlowSA (YFSA)	73,6 (± 2,8) ^{A}	39,9 (± 1,9) ^{A}

Letras maiúsculas sobrescritas diferentes representam diferença estatisticamente significativa para o grau de conversão ($p < 0,001$) e microdureza superficial ($p < 0,04$).

Fonte: Elaborado pelos autores.

DISCUSSÃO

Este estudo comparou o grau de conversão (GC) de uma resina composta fluida convencional (Yflow) e uma resina composta fluida autoadesiva (Yflow SA). O grau de conversão é uma característica crucial para o desempenho clínico, das resinas fluidas e as autoadesivas.[13] Este teste mede a porcentagem de ligações duplas monoméricas (C=C) que se transformam em ligações simples de polímeros (C-

C) durante a reação de fotopolimerização. Portanto, o método utilizado para essa análise incluiu a avaliação das alterações nas bandas de absorção ou dispersão dos grupos funcionais C=C dos monômeros antes e depois da polimerização, onde a redução da intensidade dessas bandas após a fotoativação é diretamente proporcional ao GC. À medida que a luz penetra no compósito, a fotopolimerização é progressivamente atenuada, e a profundidade de cura diminui conforme a luz se desloca em direção ao interior do incremento.[18] Um grau de conversão elevado é desejável, pois indica uma maior formação da rede polimérica, resultando em melhores propriedades físico-mecânicas e menor liberação de monômeros residuais.[14] Pois, para considerar que o procedimento restaurador foi bem-sucedido, o grau de conversão deve ser maior que 60%.[15] Contudo, devemos considerar elementos que podem afetar a polimerização como: a distância do corpo de prova em relação a ponteira do fotopolimerizador, a qualidade, e a calibração correta com o nível de irradiância adequado.[16,17] Nesse sentido, a hipótese nula foi rejeitada, já que a resina Yflow SA apresentou um grau de conversão de monômeros em polímeros, superior ao da resina YFlow ($p < 0,001$). A literatura corrobora os resultados obtidos em nosso estudo. Nakano *et al.,* (2020) avaliaram seis resinas fluida, sendo quatro convencionais e duas autoadesivas, observando graus de conversão entre 53 e 64 por cento para as resinas convencionais.

Nossos achados demonstram concordância com esses dados, uma vez que a resina convencional YFlow apresentou grau de conversão de 56,2%, valor que se situa dentro da faixa reportada pela literatura. No que diz respeito às resinas autoadesivas, os valores encontrados por Nakano *et al.,* (2020) superaram 60%, resultado que se alinha com nossos dados experimentais. Especificamente, a resina fluida autoadesiva Yflow SA apresentou grau de conversão significativamente maior (73,6%) em nossos testes, reforçando a tendência observada em estudos prévios. Para as resinas fluida autoadesivas, o teste de GC é ainda mais relevante. A inclusão de monômeros ácidos e iniciadores na mesma formulação, busca promover a adesão que pode impactar a cinética de polimerização e, por conseguinte, o grau de conversão.[19] Os compostos ácidos presentes na Yflow SA possuem dois grupos metacrilatos polimerizáveis que podem aumentar o fator de polimerização desses materiais. [20] Porém, a simplificação do protocolo, além de reduzir o tempo clínico, promove uma maior previsibilidade do tratamento. [21]

No segundo teste, referente à microdureza, os resultados mostraram que a resina Yflow SA apresentou microdureza superior à resina Yflow convencional, com diferença estatisticamente significativa (p <0,04). Dessa forma, a hipótese nula também foi rejeitada para a microdureza. Sabe-se que a resistência da resina está correlacionada à qualidade de sua matriz e à quantidade de carga, pois a inclusão de carga em certa porcentagem pode aprimorar suas propriedades mecânicas. [22,23] A microdureza é uma propriedade físico-mecânica fundamental para a avaliação de materiais odontológicos, especialmente em resinas compostas fluida, tanto convencionais quanto autoadesivas. Ela reflete a resistência de um material à deformação plástica permanente quando exposto a uma carga localizada, funcionando como um indicador crucial da eficácia da polimerização e da integridade superficial da restauração.[24] O teste utilizado para essa medição é o teste de dureza Vickers (VHN), que envolve a aplicação de um indentador em formato de pirâmide à superfície do material, com a dimensão da indentação sendo avaliada sob microscopia.[25,26] Parte da literatura apresenta resultados similares aos encontrados em nosso estudo, Azizi F. *et al.,* (2023) realizou um estudo com cinco resinas fluida, três delas convencionais, uma autoadesiva e uma resina composta bulkfill. As resinas fluidas autoadesivas apresentaram teste de dureza Vickers resultando em 47,39 HV. Em nosso estudo, a resina autoadesiva Yflow SA da Yller, apresentou valor de teste de dureza similar, obtendo um total de 39,9 HV. Os valores obtidos por esse estudo, em relação às resinas fluidas convencionais, obtiveram valores discrepantes ao teste realizado em nosso estudo. O teste de dureza de Vickers em nosso estudo apresentou um resultado cerca de duas vezes menor em relação aos resultados encontrados na literatura. Isso pode ser explicado pelo uso de resinas diferentes nos estudos mencionados. Dessa forma, não é possível comparar diretamente resinas de marcas diferentes, já que cada material tem suas peculiaridades no processo de fabricação, tais como: sistema de iniciação de polimerização diferentes, quantidade e volume de cargas diferentes, tipos de cargas diferentes, dentre outros. [27]

Para as resinas fluida, a microdureza reflete diretamente o grau de conversão dos monômeros em polímeros. Uma polimerização incompleta resulta em um grau de conversão baixo, o que, por sua vez, leva a uma microdureza reduzida. Isso compromete a resistência da restauração à abrasão, desgaste e deformação sob forças mastigatórias, diminuindo sua longevidade clínica. [28] Estudos na literatura,

como os mencionados anteriormente, frequentemente exploram a correlação entre o grau de conversão e a microdureza, confirmando a importância desse teste como um indicativo indireto da polimerização.[29] A profundidade de polimerização é outro fator intimamente relacionado à microdureza. Em camadas mais profundas de resinas fluida, a atenuação da luz pode resultar em um grau de conversão inferior e, consequentemente, em uma microdureza menor nessas áreas.[23,30] Para as resinas fluida autoadesivas, a avaliação da microdureza adquire uma dimensão adicional. A presença de monômeros funcionais ácidos, que favorecem a autoadesão, pode influenciar a cinética de polimerização e, potencialmente, a formação da rede polimérica.[31] Em resumo, a microdureza é um parâmetro fundamental na pesquisa e desenvolvimento de resinas fluida, pois esse teste permite compreender a eficácia da polimerização e a resistência superficial, fornecendo dados valiosos para a seleção e aplicação clínica desses materiais.[32]

CONCLUSÃO

Considerando os dados obtidos e dentro das limitações deste estudo, a resina composta fluida autoadesiva (Yflow SA) demonstrou desempenho significativamente superior à resina composta fluida convencional (Yflow) em ambas as propriedades avaliadas. Os resultados revelaram diferenças estatisticamente significativas tanto no grau de conversão quanto na microdureza superficial, indicando que resina autoadesiva pode oferecer vantagens em relação à convencional, possivelmente devido a componentes químicos específicos de sua formulação, que produzem um mecanismo de polimerização mais eficiente. No entanto, estudos adicionais são necessários para avaliar se essas vantagens observadas em condições laboratoriais se mantêm em situações clínicas ao longo do tempo.

REFERÊNCIAS

[1]. Meireles MR, Batista D de O, Freire ES, Torres A da S, Isolan CP, Torres M de M, *et al.,*. Resinas compostas autoadesivas: uma alternativa ao uso dos sistemas adesivos. REVISTA DO CROMG [Internet]. 2023 [cited 2024 Mar 6];22(Supl.4). Available from: https://revista.cromg.org.br/index.php/rcromg/article/view/505

[2]. German MJ. Developments in resin-based composites. British Dental Journal [Internet]. 2022 May 1;232(9):638–43. Available from: https://www.nature.com/articles/s41415-022-4240-8

[3]. Despoina Bompolaki, Lubisich EB, Paula A. Resin-Based Composites for Direct and Indirect Restorations. Dental Clinics of North America. 2022 Sep 1;66(4):517–36.

[4]. Jang J-H, Park S-H, Hwang I-N. Polymerization Shrinkage and Depth of Cure of Bulk-Fill Resin Composites and Highly Filled Flowable Resin. Operative Dentistry. 2015 Mar;40(2):172–80.

[5]. Vaidyanathan TK, Vaidyanathan J. Recent advances in the theory and mechanism of adhesive resin bonding to dentin: A critical review. Journal of Biomedical Materials Research Part B: Applied Biomaterials. 2009 Feb;88B(2):558–78.

[6]. Nakano E, de Souza A, Boaro L, Catalani L, Braga R, Gonçalves F. Polymerization Stress and Gap Formation of Self-adhesive, Bulk-fill and Flowable Composite Resins. Operative Dentistry. 2020 Jun 5;

[7]. Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dental Materials. 1999 Mar;15(2):128–37.

[8]. David C, Cardoso de Cardoso G, Isolan CP, Piva E, Moraes RR, Cuevas-Suarez CE. Bond strength of self-adhesive flowable composite resins to dental tissues: A systematic review and meta-analysis of in vitro studies. The Journal of Prosthetic Dentistry. 2021 Apr;

[9]. Zanatta CTI, Silva SV da, Bonamin S, Camilotti V, Mendonça MJ, Ueda JK. Avaliação da resistência ao cisalhamento de resinas compostas flow autoadesivos versus convencionais: uma revisão sistemática. Research, Society and Development. 2022 Jan 23;11(2):e20211225576.

[10]. Vichi A, Margvelashvili M, Goracci C, Papacchini F, Ferrari M. Bonding and sealing ability of a new self-adhering flowable composite resin in class I restorations. Clinical Oral Investigations. 2012 Oct 20;17(6):1497–506.

[11]. Mair LH, Stolarski TA, Vowles RW, Lloyd CH. Wear: mechanisms, manifestations and measurement. Report of a workshop. Journal of Dentistry. 1996 Jan;24(1-2):141–8.

[12]. Natsu Sumino, Tsubota K, Toshiki Takamizawa, Koji Shiratsuchi, Miyazaki M, Latta MA. Comparison of the wear and flexural characteristics of flowable resin composites for posterior lesions. 2013 May 3;71(3-4):820–7.

[13]. Ercoli C, Tarnow D, Poggio CE, Tsigarida A, Ferrari M, Caton JG, *et al.,*. The Relationships Between Tooth-Supported Fixed Dental Prostheses and Restorations and the Periodontium. Journal of Prosthodontics. 2020 Dec 10;30(4):305–17.

[14]. Tabassum S, Muhammad Hasan Hameed, Farhan Raza Khan. Comparison of the depth of cure of flowable composites polymerized at variable increment thicknesses and voltages: An In vitro study. Contemporary clinical dentistry [Internet]. 2019 Jan 1 [cited 2024 May 27];10(2):220–0. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7145244/

[15]. Menon, A., Ganapathy, D. M., & Mallikarjuna, A. V. (2019). Factors that influence the colour stability of composite resins. Drug Invention Today, 11(3), 50-62.

[16]. Pérez-Mondragón AA, Cuevas-Suárez CE, José Abraham González-López, Nayely Trejo-Carbajal, Meléndez-Rodríguez M, Herrera-González AM. Preparation and evaluation of a BisGMA-free dental composite resin based on a novel trimethacrylate monomer. Dental Materials. 2020 Feb 12;36(4):542–50.

[17]. Murariu A, Dinu C, Doriana Agop Forna, Stefanescu V, Iordache C. Composite Resins - Multifunctional Restorative Material and Practical Approaches in Dental Field. Materiale Plastice [Internet]. 2019 Jul 1;57(2):276–84. Available from: https://www.researchgate.net/publication/342593307_Composite_Resins_-_Multifunctional_Restorative_Material_and_Practical_Approaches_in_Dental_Field

[18]. Ranjbar Omrani L, Abbasi M, Motevasselian F, Yektaei MA, Najafi F. Degree of conversion and water sorption of self-adhesive and conventional flowable composites. Brazilian Journal of Oral Sciences. 2021 Jan 4;19:e208556.

[19]. Hanabusa M, Mine A, Kuboki T, Momoi Y, Van Landuyt KL, Van Meerbeek B, *et al.,*. TEM interfacial characterization of an experimental self-adhesive filling material bonded to enamel/dentin. Dental Materials. 2011 Aug;27(8):818–24.

[20]. David C, Cuevas-Suárez C, de Cardoso G, Isolan C, de Moraes R, da Rosa W, *et al.,*. Characterization of Contemporary Conventional, Bulk-fill, and Self-adhesive Resin Composite Materials. Operative Dentistry. 2022 Jul 1;47(4):392–402.

[21]. Carbo LC, Jesus E de, Miguel. Avaliação do uso das resinas autoadesivas em diferentes tipos de restaurações. Revista Sociedade Científica. 2024 Nov 14;7(1):5450–70.

[22]. Hashemikamangar SS, Zeynaddini meymand M, Kharazifard MJ, Valizadeh S. Surface microhardness of a self-adhesive composite in comparison with conventional composite resins. Dental and Medical Problems. 2020 Sep 30;57(3):247–53.

[23]. Rodriguez A, Yaman P, Dennison J, Garcia D. Effect of Light-Curing Exposure Time, Shade, and Thickness on the Depth of Cure of Bulk Fill Composites. Operative Dentistry. 2017 Sep;42(5):505–13.

[24]. Bianchi EC, Aguiar PR de, Alves MCS, Freitas CA de, Rodrigues AR, Carvalho Jr. OB de. Comparação dos valores de desgaste abrasivo e de microdureza de 13 resinas compostas usadas em odontologia através do método do disco retificado. Polímeros. 2007 Jun;17(2):130–6.

[25]. IMAI, A. *et al.,*. Interrelation among the handling, mechanical, and wear properties of the newly developed flowable resin composites. *Journal of the Mechanical Behavior of Biomedical Materials*, v. 89, p. 72–80, 2018.

[26]. Chinelatti MA, Chimello DT, Ramos RP, Palma-Dibb RG. Evaluation of the surface hardness of composite resins before and after polishing at different times. Journal of Applied Oral Science [Internet]. 2006 Jun 1;14(3):188-92. Available from: https:// www.ncbi.nlm.nih.gov/pmc/articles/ PMC4327195/

[27]. Azizi F, Ezoji F, Khafri S, Esmaeili B. Surface Micro-Hardness and Wear Resistance of a Self-Adhesive Flowable Composite in Comparison to Conventional Flowable Composites. Frontiers in Dentistry. 2023 May 2;

[28]. Strazzi-Sahyon H, Rocha E, Assunção W, dos Santos P. Influence of Light-Curing Intensity on Color Stability and Microhardness of Composite Resins. The International Journal of Periodontics & Restorative Dentistry. 2020 Jan;40(1):129- 34.

[29]. Neves AD, Augusto J, Oréfice RL, Jansen WC. Correlação entre grau de conversão, microdureza e conteúdo inorgânico em compósitos. Pesquisa Odontológica Brasileira. 2002 Dec 1;16(4):349-54.

[30]. Tsai P. Depth of cure and surface microhardness of composite resin cured with blue LED curing lights. Dental Materials. 2004 May;20(4):364-9.

[31]. Basheer RR, Hasanain FA, Abuelenain DA. Evaluating flexure properties, hardness, roughness and microleakage of high-strength injectable dental composite: an in vitro study. BMC Oral Health. 2024 May 10;24(1).

[32]. Saati K, Khansari S, Mahdisiar F, Valizadeh S. Evaluation of Microhardness of Two Bulk-fill Composite Resins Compared to a Conventional Composite Resin on surface and in Different Depths. Journal of dentistry (Shiraz, Iran) [Internet]. 2022;23(1):58–64. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8918645/#:~:text=The%20depth%2Dto%2Dsurface%20microhardness

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REFERÊNCIAS

MEIRELES, M. R. *et al..* Resinas compostas autoadesivas: uma alternativa ao uso dos sistemas adesivos. ***Revista do CROMG***, [S. l.], v. 22, n. Supl. 4, 2024. DOI: 10.61217/rcromg.v22.505.

GERMAN, M. J. Developments in resin-based composites. **British dental journal**, v. 232, n. 9, p. 638–643, 2022.

BOMPOLAKI, D.; LUBISICH, E. B.; FUGOLIN, A. P. Resin-based composites for direct and indirect restorations: Clinical applications, recent advances, and future trends. **Dental clinics of North America**, v. 66, n. 4, p. 517–536, 2022.

JANG, J. H.; PARK, S. H.; HWANG, I. N. Polymerization shrinkage and depth of cure of bulk-fill resin composites and highly filled flowable resin. ***Operative Dentistry***, v. 40, n. 2, p. 172–180, mar./abr. 2015. DOI: 10.2341/13-307-L.

VAIDYANATHAN, T. K.; VAIDYANATHAN, J. Recent advances in the theory and mechanism of adhesive resin bonding to dentin: a critical review**. *Journal of Biomedical Materials Research. Part B: Applied Biomaterials*,** v. 88, n. 2, p. 558–578, 2009. DOI: https://doi.org/10.1002/jbm.b.31253.

NAKANO, E. L. *et al..* Polymerization stress and gap formation of self-adhesive, bulk-fill and flowable composite resins. ***Operative Dentistry*,** v. 45, n. 6, p. e308–e316, 2020. DOI: https://doi.org/10.2341/19-166-L.

LABELLA, R. *et al..* Polymerization shrinkage and elasticity of flowable composites and filled adhesives. **Dental Materials,** v. 15, n. 2, p. 128–137, mar. 1999. DOI: 10.1016/S0109-5641(99)00022-6.

DAVID, C. *et al..* Bond strength of self-adhesive flowable composite resins to dental tissues: a systematic review and meta-analysis of in vitro studies**. *Journal of Prosthetic Dentistry*,** v. 128, n. 5, p. 876–885, nov. 2022. DOI: 10.1016/j.prosdent.2021.02.020.

ZANATTA, C. T. I. *et al..* Shear strength evaluation of self-adhesive versus conventional flow composites resins: a systematic review. ***Research, Society and Development*,** [S. l.], v. 11, n. 2, p. e20211225576, 2022. DOI: 10.33448/rsd-v11i2.25576.

Vichi A, Margvelashvili M, Goracci C, Papacchini F, Ferrari M. Bonding and sealing ability of a new self-adhering flowable composite resin in class I restorations. **Clin Oral Investig.** 2013 Jul;17(6):1497-506. doi: 10.1007/s00784-012-0846-6.

MAIR, L. H. *et al..* Wear: mechanisms, manifestations and measurement. Report of a workshop. ***Journal of Dentistry*,** v. 24, p. 141–148, 1996. DOI: 10.1016/0300-5712(95)00043-7.

SUMINO, N. *et al..* Comparison of the wear and flexural characteristics of flowable resin composites for posterior lesions. ***Acta Odontologica Scandinavica***, v. 71, n. 3–4, p. 820–827, 2013. DOI: https://doi.org/10.3109/00016357.2012.734405.

ERCOLI, C. *et al..* The relationships between tooth-supported fixed dental prostheses and restorations and the periodontium. ***Journal of Prosthodontics*****,** v. 30, n. 4, p. 305–317, 2021.

TABASSUM, S.; HAMEED, M. H.; KHAN, F. R. Comparison of the depth of cure of flowable composites polymerized at variable increment thicknesses and voltages: an in vitro study**.** ***Contemporary Clinical Dentistry*****,** v. 10, n. 2, p. 220–225, 2019. DOI: 10.4103/ccd.ccd_635_18.

MENON, A.; GANAPATHY, D. M.; MALLIKARJUNA, A. V. Factors that influence the colour stability of composite resins. ***Drug Invention Today***, v. 11, n. 3, p. 50–62, 2019.

PÉREZ, M. A. A. *et al..* Preparation and evaluation of a BisGMA-free dental composite resin based on a novel trimethacrylate monomer. ***Dental Materials***, v. 36, n. 4, p. 542–550, 2020.

MURARIU, A. *et al..* Composite resins – multifunctional restorative material and practical approaches in dental field**. Materiale Plastice**, v. 57, n. 2, p. 276–284, 2019. DOI: https://doi.org/10.37358/mp.20.2.5373.

OMRANI, L. *et al..* Degree of conversion and water sorption of self-adhesive and conventional flowable composites: an in vitro study**.** ***Brazilian Journal of Oral Sciences*****,** v. 19, e208556, 2021. DOI: 10.20396/bjos.v19i0.8658556.

HANABUSA, M. *et al..* TEM interfacial characterization of an experimental self-adhesive filling material bonded to enamel/dentin. ***Dental Materials***, v. 27, n. 8, p. 818–824, 2011. DOI: 10.1016/j.dental.2011.04.007.

DAVID, C. *et al..* Characterization of Contemporary Conventional, Bulk-fill, and Self-adhesive Resin Composite Materials. **Operative Dentistry**, v. 47, n. 4, p. 392–402, 1 jul. 2022.

CARBO, L. C.; DE JESUS, E.; DE OLIVEIRA, J. M. Avaliação do uso das resinas autoadesivas em diferentes tipos de restaurações. ***Revista Sociedade Científica*****,** v. 7, n. 1, p. 5450–5470, 2024. DOI: https://doi.org/10.61411/rsc202486017.

HASHEMIKAMANGAR, S. S. *et al..* Surface microhardness of a self-adhesive composite in comparison with conventional composite resins. ***Dent Med Probl.*****,** v. 57, n. 3, p. 247–253, jul./set. 2020. DOI: 10.17219/dmp/118123.

RODRIGUEZ, A. *et al..* Effect of lightcuring exposure time, shade, and thickness on the depth of cure of bulk fill composites. ***Operative Dentistry*****,** v. 42, n. 5, p. 505–513, 2017

BIANCHI, E. C. *et al..* Comparação dos valores de desgaste abrasivo e de microdureza de 13 resinas compostas usadas em odontologia através do método do disco retificado**.** ***Polímeros***, v. 17, n. 2, p. 130–136, 2007. DOI: https://doi.org/10.1590/S0104-14282007000200012.

IMAI, A. *et al..* Interrelation among the handling, mechanical, and wear properties of the newly developed flowable resin composites. ***Journal of the Mechanical Behavior of Biomedical Materials*****,** v. 89, p. 72–80, 2018.

CHINELATTI, M. A. *et al..* Evaluation of the surface hardness of composite resins before and after polishing at different times. ***Journal of Applied Oral Science*****,** v. 14, n. 3, p. 188–192, 2006.

AZIZI, F. *et al..* Surface micro-hardness and wear resistance of a self-adhesive flowable composite in comparison to conventional flowable composites. ***Frontiers in Dentistry***, v. 20, p. 10, 2023. DOI: https://doi.org/10.18502/fid.v20i10.12609

STRAZZI-SAHYON, H. B. *et al..* Influence of light-curing intensity on color stability and microhardness of composite resins. ***International Journal of Periodontics & Restorative Dentistry*****,** v. 40, n. 1, p. 129–134, 2020.

NEVES, A. D. *et al..* Correlação entre grau de conversão, microdureza e conteúdo inorgânico em compósitos. ***Pesquisa Odontológica Brasileira*****,** v. 16, n. 4, p. 349–354, 2002. DOI: https://doi.org/10.1590/S1517-74912002000400012.

TSAI, P. Depth of cure and surface microhardness of composite resin cured with blue LED curing lights. ***Dental Materials*****,** v. 20, n. 4, p. 364–369, maio 2004.

BASHEER, R. R.; HASANAIN, F. A.; ABUELENAIN, D. A. Evaluating flexure properties, hardness, roughness and microleakage of high-strength injectable dental composite: an in vitro study. ***BMC Oral Health***, v. 24, 546, 2024. DOI: https://doi.org/10.1186/s12903-024-04333-3.

SAATI, K. *et al..* Evaluation of microhardness of two bulk-fill composite resins compared to a conventional composite resin on surface and in different depths. ***Journal of Dentistry (Shiraz, Iran)*****,** v. 23, n. 1, p. 58–64, 2022. DOI: https://doi.org/10.30476/dentjods.2021.87669.1278.

APÊNDICE A-
Relatório da análise estatística grau de conversão

Teste de normalidade (Shapiro-Wilk)

Tabela 1. Test of Normality (Shapiro-Wilk)

		W	p
Degree of conversion (%)	YF	0.977	0.883
	YFSA	0.834	0.179

Note. Significant results suggest a deviation from normality.

Teste de igualdade de variâncias (Levene's)

Tabela 2. Test of Equality of Variances (Levene's)

	F	df_1	df_2	p
Degree of conversion (%)	0.781	1	6	0.411

Teste T (student)

Tabela 3. Independent Samples T-Test

	t	df	p
Degree of conversion (%)	-6.409	6	< .001

Note. Student's t-test.

Tabela 4.

	Grau de conversão (%)	
	YF	YFSA
Média	56.21^{B}	73.56^{A}
Desvio padrão	4.622	2.820

Letras maiúsculas sobrescritas diferentes representam diferença estatisticamente significativa ($p < 0,001$).

APÊNDICE B
Relatório do teste estatístico Microdureza Vickers

Teste de normalidade (Shapiro-Wilk)

Tabela 5. Test of Normality (Shapiro-Wilk)

		W	p
Microdureza	YF	0.946	0.709
	YFSA	0.950	0.737

Note. Significant results suggest a deviation from normality.

Teste de igualdade de variâncias (Levene's)

Tabela 6. Test of Equality of Variances (Levene's)

	F	df_1	df_2	p
Microdureza	0.006	1	8	0.942

Teste T (student)

Tabela 7. Independent Samples T-Test

	t	df	p
Microdureza (HV)	-2.447	8	< .040

Note. Student's t-test.

ANEXO A
Diretrizes da revista Copiar e colar nome da revista e diretrizes.

About the journal

Aims and scope

The International Journal of Adhesion and Adhesives draws together the many aspects of the science and technology of adhesive materials, from fundamental research and development work to industrial applications. Subject areas covered include: interfacial interactions, surface chemistry, methods of testing, accumulation of test data on physical and mechanical properties, environmental effects, new adhesive materials, sealants, design of bonded joints, and manufacturing technology. The IJAA also welcomes scientifically robust research and reviews on the developments of technologies related to hard and soft tissue adhesion of dental and biomedical materials.
The IJAA does NOT deal with soldering and welding. The above list is not exhaustive but the editors will reject any proposed papers which they consider to outside the scope of the journal.

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- Review Papers.
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This journal follows a single anonymized review process. Your submission will initially be assessed by our editors to determine suitability for publication in this journal. If your submission is deemed suitable, it will typically be sent to a minimum of two reviewers for an independent expert assessment of the scientific quality. The decision as to whether your article is accepted or rejected will be taken by our editors.

Read more about peer review.

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Authors may submit a formal appeal request to the editorial decision, provided the it meets the requirements and follows the procedure outlined in Elsevier's Appeal Policy. Only one appeal per submission will be considered and the appeal decision will be final.

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The peer review process for special issues and article collections follows the same process as outlined above for regular submissions, except, a guest editor may send the submissions out to the reviewers and may recommend a decision to the journal editor. The journal editor oversees the peer review process of all special issues and article collections to ensure the high standards of publishing ethics and responsiveness are respected and is responsible for the final decision regarding acceptance or rejection of articles.

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Ethics in publishing

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All authors should have made substantial contributions to all of the following:

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2. Drafting the article or revising it critically for important intellectual content.
3. Final approval of the version to be submitted.

Authors should appoint a corresponding author to communicate with the journal during the editorial process. All authors should agree to be accountable for all aspects of the work to ensure that the questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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The editors of this journal generally will not consider changes to authorship once a manuscript has been submitted. It is important that authors carefully consider the authorship list and order of authors and provide a definitive author list at original submission.

The policy of this journal around authorship changes:

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All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence or bias their work. Examples of potential competing interests include:

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The resulting Word document containing your declaration should be uploaded at the "attach/upload files" step in the submission process. It is important that the Word document is saved in the .doc/.docx file format. Author signatures are not required.

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List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants, scholarships and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, it is recommended to include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Authors must declare the use of generative AI in scientific writing upon submission of the paper. The following guidance refers only to the writing process, and not to the use of AI tools to analyse and draw insights from data as part of the research process:

- Generative AI and AI-assisted technologies should only be used in the writing process to improve the readability and language of the manuscript.
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- Authors must not list or cite AI and AI-assisted technologies as an author or co-author on the manuscript since authorship implies responsibilities and tasks that can only be attributed to and performed by humans.

The use of generative AI and AI-assisted technologies in scientific writing must be declared by adding a statement at the end of the manuscript when the paper is first submitted. The statement will appear in the published work and should be placed in a new section before the references list. An example:

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The declaration does not apply to the use of basic tools, such as tools used to check grammar, spelling and references. If you have nothing to disclose, you do not need to add a statement.

Please read Elsevier’s author policy on the use of generative AI and AI-assisted technologies, which can be found in our GenAI Policies for journals.

Please note: to protect authors’ rights and the confidentiality of their research, this journal does not currently allow the use of generative AI or AI-assisted technologies such as ChatGPT or similar services by reviewers or editors in the peer review and manuscript evaluation process, as is stated in our GenAI Policies for journals. We are actively evaluating compliant AI tools and may revise this policy in the future.

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In support of open science this journal offers authors a free preprint posting service on SSRN to ensure early registration and dissemination of research and facilitate early citations and collaboration. Posting to SSRN is subject to SSRN's standard checks.

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Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Authors should ensure their work uses inclusive language throughout and contains nothing which might imply one individual is superior to another on the grounds of:

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- culture
- sexual orientation
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We recommend avoiding the use of descriptors about personal attributes unless they are relevant and valid. Write for gender neutrality with the use of plural nouns ("clinicians, patients/clients") as default. Wherever possible, avoid using "he, she," or "he/she."

No assumptions should be made about the beliefs of readers and writing should be free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions.

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There is no single, universally agreed-upon set of guidelines for defining sex and gender. We offer the following guidance:

- Sex and gender-based analyses (SGBA) should be integrated into research design when research involves or pertains to humans, animals or eukaryotic cells. This should be done in accordance with any requirements set by funders or sponsors and best practices within a field.
- Sex and/or gender dimensions of the research should be addressed within the article or declared as a limitation to the generalizability of the research.

- Definitions of sex and/or gender applied should be explicitly stated to enhance the precision, rigor and reproducibility of the research and to avoid ambiguity or conflation of terms and the constructs to which they refer.

We advise you to read the Sex and Gender Equity in Research (SAGER) guidelines and the SAGER checklist (PDF) on the EASE website, which offer systematic approaches to the use of sex and gender information in study design, data analysis, outcome reporting and research interpretation.

For further information we suggest reading the rationale behind and recommended use of the SAGER guidelines.

Definitions of sex and/or gender

We ask authors to define how sex and gender have been used in their research and publication. Some guidance:

- Sex generally refers to a set of biological attributes that are associated with physical and physiological features such as chromosomal genotype, hormonal levels, internal and external anatomy. A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth") and is in most cases based solely on the visible external anatomy of a newborn. In reality, sex categorizations include people who are intersex/have differences of sex development (DSD).
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- Save files in an editable format, using the extension .doc/.docx for Word files and .tex for LaTeX files. A PDF is not an acceptable source file.
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- Journal Article Publishing Support Center LaTeX FAQs and support
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You are required to provide a concise and factual abstract which does not exceed 250 words. The abstract should briefly state the purpose of your research, principal results and major conclusions. Some guidelines:

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- Avoid non-standard or uncommon abbreviations. If any are essential to include, ensure they are defined within your abstract at first mention.

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Highlights are a short collection of bullet points that should capture the novel results of your research as well as any new methods used during your study. Highlights will help increase the discoverability of your article via search engines. Some guidelines:

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- Denote powers of e by exp.
- Display equations separately from your text, numbering them consecutively in the order they are referred to within your text.

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- Place tables next to the relevant text or on a separate page(s) at the end of your article.
- Cite all tables in the manuscript text.
- Number tables consecutively according to their appearance in the text.
- Please provide captions along with the tables.
- Place any table notes below the table body.
- Avoid vertical rules and shading within table cells.

We recommend that you use tables sparingly, ensuring that any data presented in tables is not duplicating results described elsewhere in the article.

Figures, images and artwork

Figures, images, artwork, diagrams and other graphical media must be supplied as separate files along with the manuscript. We recommend that you read our detailed artwork and media instructions. Some excerpts:

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When your artwork is finalized, "save as" or convert your electronic artwork to the formats listed below taking into account the given resolution requirements for line drawings, halftones, and line/halftone combinations:

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All images must have a caption. A caption should consist of a brief title (not displayed on the figure itself) and a description of the image. We advise you to keep the amount of text in any image to a minimum, though any symbols and abbreviations used should be explained.

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We encourage the use of supplementary materials such as applications, images and sound clips to enhance research. Some guidelines:

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- Cite all supplementary files in the manuscript text.
- Submit supplementary materials at the same time as your article. Be aware that all supplementary materials provided will appear online in the exact same file type as received. These files will not be formatted or typeset by the production team.
- Include a concise, descriptive caption for each supplementary file describing its content.
- Provide updated files if at any stage of the publication process you wish to make changes to submitted supplementary materials.
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- Switch off the option to track changes in Microsoft Office files. If tracked changes are left on, they will appear in your published version.

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This journal accepts video material and animation sequences to support and enhance your scientific research. We encourage you to include links to video or animation files within articles. Some guidelines:

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- Clearly label files ensuring the given file name is directly related to the file content.
- Provide files in one of our recommended file formats. Files should be within our preferred maximum file size of 150 MB per file, 1 GB in total.
- Provide "stills" for each of your files. These will be used as standard icons to personalize the link to your video data. You can choose any frame from your video or animation or make a separate image.
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We publish all video and animation files supplied in the electronic version of your article.

For more detailed instructions, we recommend that you read our guidelines on submitting video content to be included in the body of an article.

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Please read our guidelines on sharing research data for more information on depositing, sharing and using research data and other relevant research materials.

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- Use the numbering format when cross-referencing within your article. Do not just refer to "the text."
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- Do not include the article abstract within section numbering.

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The theory section should lay the foundation for further work by extending the background you provided in the introduction to your article. The calculation section should represent a practical development from a theoretical basis.

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Please provide definitions of field-specific terms used in your article, in a separate list.

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We advise you to use footnotes sparingly. If you include footnotes in your article, ensure that they are numbered consecutively.

You may use system features that automatically build footnotes into text. Alternatively, you can indicate the position of footnotes within the text and present them in a separate section at the end of your article.

Acknowledgements

Include any individuals who provided you with help during your research, such as help with language, writing or proof reading, in the acknowledgements section. Acknowledgements should be placed in a separate section which appears directly before the reference list. Do not include acknowledgements on your title page, as a footnote to your title, or anywhere else in your article other than in the separate acknowledgements section.

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Authors must disclose any funding sources who provided financial support for the conduct of the research and/or preparation of the article. The role of sponsors, if any, should be declared in relation to the study design, collection, analysis and interpretation of data, writing of the report and decision to submit the article for publication. If funding sources had no such involvement this should be stated in your submission.

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants, scholarships and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, it is recommended to include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendices

We ask you to use the following format for appendices:

- Identify individual appendices within your article using the format: A, B, etc.
- Give separate numbering to formulae and equations within appendices using formats such as Eq. (A.1), Eq. (A.2), etc. and in subsequent appendices, Eq. (B.1), Eq. (B. 2) etc. In a similar way, give separate numbering to tables and figures using formats such as Table A.1; Fig. A.1, etc.

References

References within text

Any references cited within your article should also be present in your reference list and vice versa. Some guidelines:

- References cited in your abstract must be given in full.
- We recommend that you do not include unpublished results and personal communications in your reference list, though you may mention them in the text of your article.
- Any unpublished results and personal communications included in your reference list must follow the standard reference style of the journal. In substitution of the publication date add "unpublished results" or "personal communication."
- References cited as "in press" imply that the item has been accepted for publication.

Linking to cited sources will increase the discoverability of your research.

Before submission, check that all data provided in your reference list are correct, including any references which have been copied. Providing correct reference data allows us to link to abstracting and indexing services such as Scopus, Crossref and PubMed. Any incorrect surnames, journal or book titles, publication years or pagination within your references may prevent link creation.

We encourage the use of Digital Object Identifiers (DOIs) as reference links as they provide a permanent link to the electronic article referenced.

Reference format

This journal does not set strict requirements on reference formatting at submission. Some guidelines:

- References can be in any style or format as long as the style is consistent.
- Author names, journal or book titles, chapter or article titles, year of publication, volume numbers, article numbers or pagination must be included, where applicable.
- Use of DOIs is recommended.

Our journal reference style will be applied to your article after acceptance, at proof stage. If required, at this stage we will ask you to correct or supply any missing reference data.

Reference style

Indicate references by number(s) in square brackets in line in the text. You can refer to author names within your text, but you must always give the reference number, e.g., "as demonstrated [3,6]. Barnaby and Jones [8] obtained a different result ....".

Number the references in the reference list in the order in which they appear in the text.

Please note the shortened form for last page number. e.g., 51-9, and that for more than 6 authors the first 6 should be listed followed by '*et al.,*.'.

For further details you are referred to 'Uniform Requirements for Manuscripts submitted to Biomedical Journals' (J Am Med Assoc 1997;277:927-34) and more samples of formatted references.

Abbreviate journal names according to the List of Title Word Abbreviations (LTWA).

Examples:

Reference to a journal publication:

[1] Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. J Sci Commun 2020;163:51-9. https://doi.org/10.1016/j.sc.2020.00372.

Reference to a journal publication with an article number:

[2] Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. Heliyon. 2022;19:e00205. https://doi.org/10.1016/j.heliyon.2022.e00205.

Reference to a book:

[3] Strunk Jr W, White EB. The elements of style. 4th ed. New York: Longman; 2000.

Reference to a chapter in a book:

[4] Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, Smith RZ, editors. Introduction to the electronic age, New York: E-Publishing Inc; 2023, p. 281-304.

Reference to a website:

[5] Cancer Research UK. Cancer statistics reports for the UK, http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/; 2023 [accessed 13 March 2023].

Reference to a dataset:

[6] Oguro M, Imahiro S, Saito S, Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions [dataset]. Mendeley Data. 2015. https://doi.org/10.17632/xwj98nb39r.1.

Reference to software:

[7] Coon E, Berndt M, Jan A, Svyatsky D, Atchley A, Kikinzon E, *et al.,*. Advanced Terrestrial Simulator (ATS). Version 0.88 [software]. Zenodo; 2020 Mar 25. https://doi.org/10.5281/zenodo.3727209.

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