UNIVERSIDADE FEDERAL DE JUIZ DE FORA
CAMPUS GOVERNADOR VALADARES
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS APLICADAS Ã SAÚDE

Jacqueline Salomão Jardim

Eficiência de retentores utilizados para restauração de dentes tratados endodonticamente e sua obtenção por meio do escaneamento intraoral. Uma revisão sistemática e de escopo

Governador Valadares
2023

Dissertação apresentada ao Programa de Pós-Graduação em Ciências Aplicadas à Saúde, da Universidade Federal de Juiz de Fora, Campus Governador Valadares, como requisito parcial à obtenção do título de Mestre em Ciências Aplicadas à Saúde, área de concentração Biociências.

Orientador: Prof. Dr. Cleidiel Aparecido Araujo Lemos

Governador Valadares

2023

Jardim, Jacqueline Salomão.
Eficiência de retentores utilizados para restauração dedentes tratados endodonticamente e sua obtenção por meio do escaneamento intraoral. Uma revisão sistemática e de escopo / Jacqueline Salomão Jardim. -- 2023.
85 f.

Orientador: Cleidiel Aparecido Araujo Lemos
Dissertação (mestrado acadêmico) - Universidade Federal de Juiz de Fora, Campus Avançado de Governador Valadares, Instituto de Ciências Biológicas. Programa de Pós-Graduação em Ciências Aplicadas à Saúde, 2023.

1. Retentores intrarradiculares. 2. Escaner intraoral. 3. Falhas. 4. Dentes tratados endodonticamente. 5. Revisão sistemática. I. Lemos, Cleidiel Aparecido Araujo, orient. II. Título.

Jacqueline Salomão Jardim

Título: Eficiência de retentores utilizados para restauração de dentes tratados endodonticamente e sua obtenção por meio do escaneamento intraoral. Uma revisão sistemática e de escopo

Dissertação apresentada ao Programa de Pós-Graduação em Ciências Aplicadas à Saúde, da Universidade Federal de Juiz de Fora, Campus Governador Valadares, como requisito parcial à obtenção do título de Mestre em Ciências Aplicadas à Saúde.

Aprovada em 30 de outubro de 2023

BANCA EXAMINADORA

Prof. Dr. Cleidiel Aparecido Araujo Lemos – Orientador(a)
Universidade Federal de Juiz de Fora, Campus Governador Valadares

Prof. Dr. Eduardo Piza Pellizzer
Universidade Estadual Paulista (UNESP)

Prof. Dr. Rafael Binato Junqueira
Universidade Federal de Juiz de Fora, Campus Governador Valadares

Dedico este trabalho à minha família,
meu suporte para que eu possa alçar meus voos
sem medo das tempestades que possam me atravessar.

AGRADECIMENTOS

Agradeço ao bondoso Deus, sempre e em primeiro lugar. Ele sempre esteve ao meu lado, me mostrando o caminho a ser trilhado, que me permitiu chegar até aqui, me estendendo as mãos nos momentos difíceis, fazendo a caminhada mais leve, ao dom da profissão a mim confiada, aos desafios apresentados e toda trajetória percorrida, que me moldou no que sou hoje. A ELE toda honra e toda glória!

À minha família, meu esposo Fabiano, meu parceiro, que há exatos 25 anos, após a graduação, continua me incentivando e apoiando, para você meu sim todo dia. Meu filho, João Pedro, você foi o primeiro motivo para eu querer acertar, afinal era a responsabilidade por outra vida, e aí você me ensinou a ser forte, você é minha calmaria. Minha filha, Clarissa, ah como é bom ter uma companheira, ouvir suas histórias, contar minhas histórias, em meio a risos de vídeos do Tik Tok e choros de vídeos da vida real, você é minha coragem. Vocês sempre compreenderam com muito amor e paciência os momentos de ausência, ansiedade e afastamento. E por fim, cobraram porque foram os primeiros a acreditar no sonho possível. Vocês representam meu desejo de persistir, ressignificar e continuar… são a razão para eu buscar sempre ser uma pessoa melhor, minha vida!

Aos meus pais, vocês fizeram tudo isso possível, acreditaram no meu sonho e o tornaram realidade, aos meus irmãos que me lançaram o desafio do vestibular, porque acreditaram em mim, ali começou a desenhar a profissional que me tornei hoje, obrigada pelo apoio e amor incondicionais e perdão pela ausência tão frequente. Vocês são meus exemplos diários!

Agradeço aos meus amigos, especialmente meu amigo, que hoje, “Doutor Warley”, meu maior incentivador desse mestrado, nunca deixou de acreditar que era possível e que eu merecia estar ali, quando eu mesma não tive essa certeza. Você me fez continuar, obrigada por tanto. Você me inspira!

Aos colegas do mestrado, em um momento tão ímpar e difícil para todos, estivemos conectados pelo mesmo sonho. Conseguimos dividir momentos agradáveis, engraçados, tensos, calorosos, ainda que separados por uma tela de computador. “Qualquer dia, amigo, a gente vai se encontrar…”

Agradeço aos professores do mestrado, por me apresentarem esse mundo da pesquisa, das dificuldades, das alegrias. A todos os meus professores, são inúmeros após tantos anos, mas consigo lembrar daqueles que conseguiram fazer diferença na minha trajetória de estudante... em vários momentos na labuta diária do consultório, suas palavras me vinham à memória e ali os problemas começavam a desenrolar, e então fazem também parte da minha vida profissional.

Agradeço aos professores da banca examinadora, pelo aceite, pelas excelentes contribuições que já fizeram e por aquelas que ainda virão.

Agradeço ao meu orientador, Cleidiel, pelos ensinamentos, pela paciência, pela compreensão, por respeitar o tempo de aprendizagem de cada um, transformando: "impossível fazer uma revisão sistemática em uma disciplina de semestre", em um trabalho concluído. É encantadora sua simplicidade e humildade, apesar da vasta bagagem que carrega. Obrigada por "orientar" com mestria o meu caminho no mestrado.

Aos funcionários da Universidade Federal de Juiz de Fora – Campus Governador Valadares, que remotamente tornaram nossa vida mais fácil, afinal, fazer tudo online foi um desafio para todos nós. Foi um aprendizado!

Obrigada às muitas pessoas que estiveram presentes e cruzaram meu caminho em algum momento, obrigada pelo algo mais acrescentado neste trabalho.

Enfim, num trabalho dessa grandeza, que se iniciou numa época tão complicada, foram inúmeros os meus desafios. Alguns mais fáceis, outros muito difíceis. Nesse momento contei com a colaboração irrestrita da minha família e do meu orientador. Me sabotei, me critiquei, duvidei de que sendo uma velha profissional de consultório, a etaridade disfarçada de aconselhamentos, e sem condições de dedicação exclusiva ao mestrado, pudesse fazê-lo, merecê-lo e defendê-lo. Resta concluí-lo.

Obrigada a todos que de alguma forma contribuíram para esse sonho.

"A suficiência dos meus méritos está

em saber que meus méritos

não são suficientes"

(Santo Agostinho)

RESUMO

Os dentes que recebem tratamento endodôntico na maioria das vezes apresentam extensa destruição coronária, seja pelo acesso endodôntico, trauma, ou processo carioso entre outras, tornando um desafio sua reconstrução, devolvendo-lhe a função no sistema estomatognático. O objetivo dessa revisão sistemática e de escopo trabalho foi fornecer suporte a estudantes e profissionais da odontologia acerca da decisão de usar ou não retentores intrarradiculares em dentes com tratamento endodôntico (DTE) e em caso de indicação para o uso, como os novos sistemas CAD/CAM e scanners intra orais (IOS), podem fornecer retentores mais ajustados ao canal radicular, garantindo maior retenção longevidade a esses elementos. O uso de retentores intrarradiculares era visto como um reforço da estrutura dentária remanescente, com o passar do tempo e a publicação de ensaios clínicos randomizados, ficou provado que eles fornecem somente suporte e retenção ao material restaurador, mas não garantem reforço à estrutura dentária. Ao contrário, podem ser responsáveis por falhas, como deslocamento, descimentação e até mesmo fraturas irreparáveis com consequente perda do elemento dental. A opção pelo não uso de retentores intrarradiculares deve se basear em uma avaliação clínica criteriosa da estrutura coronal remanescente e a área de adesividade para o material restaurador. O uso dos IOSs para confecção de retentores intrarradiculares ainda não está consolidado, uma vez que os aparelhos disponíveis diferem muito em qualidade de digitalização, técnica de escaneamento, facilidade de manuseio, formato da ponteira entre outras. Essas características podem influenciar a precisão dos IOSs, e sua capacidade de leitura no ambiente intra oral. O primeiro estudo in vitro sobre digitalização de conduto radicular foi somente em 2019, antes disso eram utilizadas técnicas que combinavam scanner de laboratório para digitalização da moldagem com digitalização de um pino de fibra dentro do conduto, com IOS, para fabricação de núcleos de preenchimento fresados que garantiam uma melhor adaptação marginal e consequente menos risco de descimentação. Portanto é possível concluir que os IOSs ainda têm muito a evoluir na digitalização de condutos radiculares, o que poderá propiciar melhores possibilidades para reconstrução de DTE com extensa destruição. A tecnologia dos sistemas adesivos também tende a evoluir constantemente e quando a opção for de reabilitação de DTE sem o uso de retentores intrarradiculares, esses novos sistemas restauradores poderão garantir mais resistência à fratura dos DTE e possibilidades de redução de falhas irreparáveis ou irreparáveis.

Palavras chave: retentores intrarradiculares, failures, scanner, CAD-CAM, digitalização

ABSTRACT

Teeth that receive endodontic treatment most often exhibit extensive coronal destruction, whether due to endodontic access, trauma, carious processes, among others, making their reconstruction challenging and restoring their function in the stomatognathic system. The aim of this systematic and scoping review was to provide support to dental students and professionals regarding the decision to use intraradicular retainers in teeth with endodontic treatment (ETT), and in cases where their use is indicated, how new CAD/CAM systems and intraoral scanners (IOS) can provide better-fitted retainers for the root canal, ensuring greater retention and longevity for these elements. The use of intraradicular retainers was once seen as reinforcement for the remaining dental structure, but over time and with the publication of randomized clinical trials, it has been proven that they provide support and retention solely to the restorative material, rather than reinforcing the dental structure. On the contrary, they can be responsible for failures such as displacement, decementation, and even irreparable fractures resulting in the loss of the dental element. The decision not to use intraradicular retainers should be based on a careful clinical evaluation of the remaining coronal structure and the bonding area for the restorative material. The use of IOS for the fabrication of intraradicular retainers is not yet well-established, as the available devices vary greatly in scanning quality, scanning technique, ease of use, and the shape of the tip, among other factors. These characteristics can influence the accuracy of IOS and their ability to scan in the intraoral environment. The first in vitro study on root canal scanning was only conducted in 2019; before that, techniques combining laboratory scanners for mold scanning with the scanning of a fiber post inside the canal using IOS were used to produce milled core fillings that ensured better marginal adaptation and reduced the risk of decementation. Therefore, it can be concluded that IOS still have a long way to go in the scanning of root canals, which could offer better possibilities for the reconstruction of teeth with extensive destruction. Adhesive system technology is also constantly evolving, and when the choice is to rehabilitate teeth with endodontic treatment without using intraradicular retainers, these new restorative systems may provide increased fracture resistance for teeth with endodontic treatment and the potential to reduce irreparable or reparable failures.

Keywords: intraradicular retainers, failures, scanner, CAD-CAM, scanning.

SUMÁRIO

1 INTRODUÇÃO

Os dentes que recebem tratamento endodôntico representam um grande desafio para os dentistas (Zicari et al., 2011) que precisam reconstruir sua porção coronária a fim de devolver sua função (Cloet et al., 2017). Estes apresentam estrutura severamente danificada, seja pelo processo carioso, trauma ou durante acesso ao sistema de canais radiculares (Morgano et al., 2004; Raedel et al., 2015). Além disso, remoção de pinos, reabsorções internas, canais muito amplos, são responsáveis por reduzir a quantidade de dentina intrarradicular remanescente (Junqueira et al., 2016) e ainda o uso de irrigantes durante instrumentação dos canais radiculares e pressão da condensação da guta percha durante a obturação do canais radiculares contribuem também para a possibilidade de fratura quando submetidos às forças de tensão oclusais funcionais e parafuncionais (Tang et al., 2010; Slutzky-Goldberg et al., 2004).

O sucesso a longo prazo dos dentes tratados endodonticamente (DTE) está diretamente associada à quantidade de estrutura coronal remanescente (Pinto etal., 2018), a presença de férula circunferencial de 1,5 a 2 mm (Koosha et al., 2023), ao gap apical (Moshonov et al., 2005), adaptação interna com menor linha de cimento (Da Costa et al., 2017), entre outros. Todos esses fatores estão relacionados à necessidade ou não da colocação de retentores intrarradiculares. O uso de retentores intrarradiculares nos elementos com extensa destruição coronária é por vezes necessária e fornece retenção e suporte para o material restaurador (Pinto etal., 2018, Zicari et al., 2011).

São vários os tipos de retentores intrarradiculares utilizados, desde os metálicos, ainda hoje muito utilizados, passando pelos de fibra de vidro (Martins et al., 2021; Salvi et al., 2007). Os pinos de fibra de vidro por apresentarem um melhor comportamento estético superior e modo de elasticidade semelhante ao da dentina ganhou a preferência sobre os pinos metálicos fundidos (Ferrari et al., 2000; Grandini et al., 2005; Salameh et al., 2006; Ferrari et al., 2007; Cagidiaco et al., 2008; Goracci et al., 2011). Tais propriedades mecânicas podem reduzir os riscos de fratura catastrófica e consequente perda do elemento dentário (Ferrari et al, 2000), aumentando a longevidade dos elementos restaurados com retentores intrarradiculares. Entretanto uma grande desvantagem destes é sua seção transversal circular, que não se adapta de forma ótima aos canais radiculares elípticos, aumentando a área de cimento entre o pino e as paredes do canal radicular e possibilitando o surgimento de falhas. (Awad e Marghalani., 2004)

Com o passar dos anos e a introdução das tecnologias digitais na odontologia, os pinos fresados se tornaram uma opção alternativa. Retentores intrarradiculares com design customizado proporciona um melhor ajuste ao canal radicular (Grandini et al., 2005). Podendo ser indicado para os canais ovais ou alargados onde os pinos pré-fabricados não conseguem se adaptar (Al Omiri et al., 2010). Um pino mais ajustado ao canal, reduz a camada de cimento (Rocha et al., 2017), diminuindo o risco de falhas como deslocamento (Balkenhol et al., 2007), melhora na retenção e resistência à fratura dos DTE (Bittner et al., 2010; da Costa et al., 2017; Tsintsadze et al., 2017). Os retentores intrarradiculares customizados são produzidos a partir da tecnologia CAD/CAM, é realizada uma varredura com um IOS direto do conduto radicular, digitalização do conduto, ou uma moldagem do conduto seja de resina acrílica, silicone, etc, e posterior varredura da própria moldagem, digitalização das impressões, ou do modelo de gesso após vazamento, digitalização dos modelos, com um scanner de laboratório (Tsintsadze et al., 2017). O primeiro relato do uso de scanner na fabricação de retentores intrarradiculares foi através de técnica indireta (moldagem do conduto) e varredura extraoral por um scanner de bancada e realizada então a fresagem de um monobloco de zircônia por Awad & Marghalani, 2007. Os scanners digitais intraorais (IOS) são definidos como equipamentos que digitalizam as arcadas dentárias através de imagens e geram um modelo utilizando a técnica de estereolitografia através de arquivos tridimensionais. Os protocolos de escaneamento variam de acordo com o modelo e fabricante (Markarian et al., 2019) e são capazes de copiar as impressões dentárias, adquirindo um grande número de imagens. As imagens obtidas são processadas por um software, para fabricação da peça, retentor intrarradicular, através da impressão de uma estrutura, por estereografia (SLA), fusão seletiva a laser (SLM) entre outras (Al Qarni., 2022). Sendo capaz de gerar cópias com uma margem mínima de erros (Cicciù et al., 2020) de materiais estéticos como PEEK (Atia et al., 2020), zircônia (Leven et al.,2022), fibra de vidro (Da Costa et al., 2022), etc e agilizando os processos laboratoriais (Kihara et al., 2019). A literatura atual concorda que retentores intrarradiculares CAD/CAM apresentam comportamento de retenção (Hendy et al., 2018), resistência à fratura (Suzaki et al.,, 2021), resistência de união e adaptação interna (Ming et al., 2023) comparados aos retentores fundidos e pré fabricados, apresentando uma boa alternativa para reconstruções dos DTE (Gutiérrez et al., 2022). Atualmente muitos IOSs têm sido lançados constantemente, sempre com diferentes características, incluindo o princípio de funcionamento da digitalização, a fonte de luz usada na digitalização, necessidade de artifícios de escaneamento como scan post ou aerossóis para revestimento do objeto a ser digitalizado (Alzahrani et al., 2020). Essas características dos IOSs podem influenciar a digitalizações, incluindo a experiência do operador (Elter et al., 2023).

Embora os retentores garantam um suporte importante para reconstrução coronária perdida, sabe-se que o pino intrarradicular não proporciona reforço aos DTE, e muitas vezes sua utilização pode causar maiores injúrias devido ao desgaste de estrutura dentária, maior tempo clínico, menor conforto ao paciente (Jurema et al., 2020), e em determinadas situações pode ocasionar a presença de algumas falhas, como a descimentação e/ou fratura radicular (Balkenhol et al., 2007).

Apesar do avanço da tecnologia na construção dos retentores intrarradiculares sua utilização nos DTE ainda não é consenso, a literatura ainda é inconclusiva sobre o uso ou não de retentores para reconstrução de DTE, seja para restaurações diretas ou indiretas (Pontoriero et al. 2021; Naumann et al. 2018).

Assim, diante da literatura inconclusiva quanto ao uso ou não de retentores intrarradiculares nos DTE, a escassez de estudos que corroborem técnicas de escaneamento que possam resultar uma melhor acurácia dos IOSs disponíveis, julgamos oportuno um estudo que possa auxiliar os profissionais na tomada de decisão quanto a escolha do uso ou não de retentores intrarradiculares e se os IOSs atualmente disponíveis seriam capazes de fornecer retentores intrarradiculares mais precisos e ajustados ao canal radicular, reduzindo assim as chances de falha das reconstruções de DTE.

Com a crescente disponibilização de novos IOSs, e a diversidade de formas de utilização, faz se necessário identificar os que podem oferecer melhores possibilidades para escaneamento de condutos radiculares. Por isso o objetivo deste estudo foi identificar através de uma revisão de escopo, as variadas técnicas para o uso de alguns IOSs disponíveis no mercado, e a influência desses modelos na confecção de retentores intrarradiculares mais precisos e ajustados ao canal radicular.

2 DESENVOLVIMENTO

2.1 ARTIGO CIENTÍFICO 1

Artigo científico enviado para publicação no periódico Dental Materials, qualis CAPES A1. A estruturação do artigo baseou-se nas instruções aos autores preconizados pelo periódico (ANEXO A).

Is an intraradicular post essential for reducing failures in the restoration of endodontically treated teeth? A systematic review and meta-analysis

Jacqueline Salomão Jardim,[1] Hiskell Francine Fernandes e Oliveira,[2] Vinicius de Menezes Félix Ferreira,[1] Cleidiel Aparecido Araujo Lemos[3]

[1]Postgraduate Program in Applied Health Sciences (PPGCAS), Federal University of Juiz de Fora (UFJF), Campus Avançado Governador Valadares, Governador Valadares, Minas Gerais, Brazil

[2]Department of Dental Materials and Prosthodontics, Sao Paulo State University (UNESP), Araçatuba, Brazil.

[3]Department of Dentistry, Federal University of Juiz de Fora (UFJF), Campus Avançado Governador Valadares, Governador Valadares, Minas Gerais, Brazil.

Corresponding author:

Cleidiel Aparecido Araujo Lemos
Department of Dentistry, Federal University of Juiz de Fora (UFJF) – Campus Avançado Governador Valadares, Governador Valadares - MG, Brazil
Email: cleidiel.lemos@ufjf.edu.br / Telefone: (33) 3301-1000 – Ramal 1580

ABSTRACT

The restoration of endodontically treated teeth (ETT) can be performed with posts or not, depending on the professional's judgment and other clinical characteristics of teeth and patients. However, no consensus has been reached about the different treatment modalities. Therefore, this systematic review aimed to assess if the use of posts contributes to reducing the failure rates of ETT when compared to reconstructions without posts. This systematic review followed PRISMA 2020 items and was registered in the international database PROSPERO (CRD42021258906). The question evaluated was: “Is an intraarticular post essential for reducing failures in restoration of endodontically treated teeth?”. An electronic database search was performed in the MEDLINE/ PubMed, Embase, Scopus, and Web of Science for articles published up to June 2021, being complemented with a search in gray literature (ProQuest and ClinicalTrials.gov). The RoB 2.0 tool was used to analyze the risk of bias, and the RevMan 5.4 program was used for meta-analysis. The searches found a total of 1139 articles, and 22 articles were selected for analysis. Of these, 13 randomized clinical trials (RCT) were included. For overall failure rates, it was possible to observe lower failure risks for restorations with posts when compared to restorations without posts (P=0.0007; Risk Ratio [RR]: 0.61). The superiority in the use of posts remained for indirect restorations (P<0.00001; RR: 0.44), prefabricated fiber posts (P<0.0001; RR: 0.54), and individualizable fiberglass posts (P=0.0004; RR: 0.66). However, no differences were observed between post or not post for direct restorations (P=0.74; RR: 1.10), cast post and core (P=0.66; RR: 0.84), and prefabricated metallic posts (P=0.67; RR: 1.19). Five of the included studies had a low risk of bias. However, the certainty of evidence was classified as low. Thus, is possible to conclude that the use of fiber posts for restorations of ETT can be used to reduce the risk of failures and root

fractures. For direct reconstructions, both the use of post can be considered optional with a choice based on the particularities of the case. However, further randomized, and well-designed clinical trials are recommended to reassess the data found due to low certainty of evidence.

Keywords: Intraradicular retainer, failures, endodontically treated teeth, direct reconstruction.

1. INTRODUCTION

The restoration of endodontically teeth treated (ETT) with extensive coronal destruction presents a challenge for dentists [1] who need to ensure their restoration to restore their function in the stomatognathic system [2], since the loss of dental structure due to carious processes, trauma, or root canal access can reduce the teeth ability to withstand masticatory stress [3,4].

Intraradicular posts have been widely used to ensure support for the restorative material and enable coronal reconstruction for direct restorations or core for indirect restorations, thus minimizing the failure risk [5]. Various types of posts are available, such as metal and fiber posts [6,7]. Although these retainers provide important support for lost coronal reconstruction, it is known that posts do not reinforce ETT, and their use can often lead to greater tooth structure wear, increased clinical time, reduced patient comfort [8], and in certain situations, may result in certain failures, such as post decementation and/or root fracture [9].

In this context, with the advancement of adhesive techniques and technological progress in restorative materials [10], the possibility of coronal reconstruction for ETT without the use of intraradicular retainers have been considered [11]. However, the literature remains inconclusive regarding whether to use retainers for the reconstruction of ETT, whether for direct or indirect restorations [12-14].

Previously reviews considered the evaluation of intraradicular posts for ETT and concluded that there was limited evidence to support the decision of whether to use these posts or not [14-18]. However, recently, new clinical trials, with randomized controlled trials (RCT) design with longer follow-up periods, have been published, and as a result, a new critical analysis of these therapeutic possibilities is warranted.

Therefore, the aim of this study was to evaluate, through a systematic review and meta-analysis, whether ETT that received intraradicular posts exhibited a higher risk of failure compared to restorations that did not utilize posts. The null hypothesis tested is that ETT with posts does not differ in terms of failure rates compared to restorations without posts.

2. METHODS

This systematic review was conducted following the guidelines of Cochrane Handbook of Systematic Reviews of Interventions [19] and reported by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement (PRISMA 2020) [20]. The systematic review has been registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the following registration number (CRD42021258906).

The formulated PICO question was: "Is an intraradicular posts essential for reducing failures in restorations of ETT compared to without the use of posts?" In this context, the selected studies included participants with ETT in at least one tooth, without specifying the type or region of the tooth. The intervention assessed was the use of intraradicular posts for coronal/core reconstruction, compared to teeth that were restored without intraradicular posts. The primary outcome of this systematic review was to compare the failure rates. Only RCT studies were included.

The eligibility criteria included studies that directly compared failure rates of ETT with or without posts. These ETTs should have received either direct restorations (resin or amalgam) or indirect restorations (partial crowns, full crowns, and veneers) for coronal reconstruction. Any type of posts was considered, including prefabricated metal posts, fiber posts (glass, carbon, and quartz), and cast posts and core. The studies should have had a minimum follow-up period of 12 months and a minimum of 10 restorations in each evaluated group. There were no language or publication date restrictions. On the other hand, non-randomized studies, case reports, in vitro studies, in silico studies, reviews, and studies that assessed only one of the groups without direct comparison within the same study were excluded.

The electronic searches were conducted by two independent researchers (J.S.J. and V.M.F.) in the following databases: MEDLINE/PubMed, Embase, Scopus, and Web of Science for articles published up to June 2022. In addition, the searches were updated in August 2023. Additionally, a search of gray literature was also performed to identify unpublished or non-peer-reviewed reports, using the ProQuest database and ClinicalTrials.gov. Specific details about the search strategies conducted in each of these databases are available in the Supplementary Table (Appendix A).

The selected studies were imported into the Rayyan QCRI Reference Manager [21] to remove duplicate studies and to review the titles and abstracts of the studies according to the pre-established inclusion criteria. After the initial selection of studies, any disagreements between the first two reviewers were resolved by a third reviewer (C.A.A.L.) to reach a consensus. Additionally, an additional search was conducted in the reference lists of the included articles to identify potential studies that met the eligibility criteria.

The selected articles that met the inclusion criteria were tabulated by one author (J.S.J.) using Microsoft Excel through a standardized data extraction form. A second author (V.M.F.) was responsible for checking the tabulated data. Data from the articles were extracted considering the following topics: Author/year of publication, patients/gender, mean age, post restorations, region rehabilitated, commercial brand (post), remaining coronal walls, crown restorations, follow-up time in months, failures, survival/success rate (%).

For the analysis of individual study bias risk, the Cochrane tool for assessing bias risk in randomized trials (RoB 2.0) [22] was used. The RoB 2.0 tool addresses five specific domains: (1) bias due to the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in outcome measurement; and (5) bias in the selection of the reported result. After evaluating these domains, an overall bias rating will be assigned to each study. Each of these domains will be categorized as low, high, or some concerns.

The meta-analysis was performed to measure the failure rates using the Mantel-Haenszel method to assess the risk ratio (RR) between the groups. The analyses were conducted with 95% confidence intervals (CIs), and significance was considered when the P-value was <0.05. In the case of high heterogeneity, a random-effects analysis was considered. Conversely, if low heterogeneity was observed, a fixed-effects analysis was considered [23]. Sub-analyses were considered to assess the influence of different posts and coronal reconstruction (direct or indirect) on the observed failure rates. Review Manager 5.4 software (Cochrane Group) was used for the meta-analysis.

The certainty of evidence was assessed using The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach. This tool allows the determination of the certainty of evidence for each outcome individually, considering characteristics such as study design, inconsistency, indirectness, imprecision, and publication bias. The certainty of evidence for each outcome can be classified at the end as high, moderate, low, or very low. To create the Summary of Findings tables, the GRADEpro GDT software (https://gdt.gradepro.org/app/) was used. An additional analysis was conducted to compare the level of inter-examiner agreement during the individualized study selection process. For this, the Kappa concordance criteria was considered [24].

3. RESULTS

The database search retrieved 1,284 from MEDLINE/PubMed, 432 from Scopus, 229 from Web of Science, 205 from Embase, and 38 from ProQuest, totaling 2,188 studies. A search in the ClinicalTrials.gov database identified a total of 42 clinical trial records. After removing duplicates, 1,593 studies remained for selection based on title and abstract. Subsequently, 22 studies were selected for full-text review, with 9 articles being excluded for various reasons: some did not include both groups within the same study [25-27], some were non-randomized articles [3,7,28,29], and some were retrospective studies [12,30]. Thus, a total of 13 studies [1,2,9,13,31-39] were included in this review, all of which were RCT studies.

The characteristics of the selected studies are summarized in Table 1. A total of

2,287 patients, including both men and women, were considered, with the sample size per study ranging from 22 to 360 individuals and ages ranging from 18 to 76 years. In total, 2,555 ETT were evaluated, with 1,807 reconstructed with intraradicular retainers and 748 without retainers, with follow-up periods ranging from 1 to 17 years.

Teeth in both the mandibular and maxillary arches were included in the studies [13,34,36,37,38]. On the other hand, Jurema et al. [9] considered only anterior maxillary elements, in contrast to other studies studies by Ferrari et al., 2007, Ferrari et al., 2012, Ferrari et al., 2019, Manocci et al., 2005, Karteva et al., 2017, Cagidiaco et al., 2008, which considered only posterior elements [13,31,32,35,36,39]. Meanwhile, other studies considered both regions [1,2,31,33,34,37,38] as represented in Table 1.

The most reported failures in the studies included root and restoration composite fractures, retention loss of pins and crowns, endodontic failures, coronal fractures, andtooth loss, among others. In the overall meta-analysis, considering the aggregation ofall failures reported by the studies, a significant favorable difference was found for thegroup with retainers compared to the group without retainers ($P = 0.0007$; Risk Ratio[RR]: 0.61; 95% Confidence Interval [CI]: 0.46 to 0.81). However, significant heterogeneity was observed ($P = 0.08$; $I^2 = 40\%$) (Figure 2).

Therefore, a sub-analysis was conducted, separating failures into root fractures compared to other types of failures. It was possible to observe a reduction in heterogeneity in the sub-analyses, but a significant favorable difference to the groups that used retainers was still maintained, both for root fractures ($P < 0.00001$; RR: 0.15; CI: 0.08 to 0.26) and for other reported failures ($P = 0.002$; RR: 0.73; CI: 0.59 to 0.89) (Figure 3).

Other variables were considered for analysis. Five studies considered direct coronal reconstruction with composite resin and/or amalgam for both the groups with and without posts [9,31,34,38,39]. Five studies considered only core reconstruction to enable indirect restoration with different materials such as veneers, crowns (partial or full) with metal or ceramic material [13,32,35,36,37], while three other studies performed direct or indirect restorations depending on the type of retainer used [1,2,33].

Through subgroup analysis of the studies that allowed for the type of restoration (direct or indirect), it was observed that the use of posts did not significantly increase failures compared to the non-use of posts for direct restorations ($P = 0.74$; RR: 1.10; CI: 0.64 to 1.87). Conversely, when analyzing the influence of posts for indirect restorations, the non-use of posts significantly increased failure rates of core restorations ($P < 0.00001$; RR: 0.44; CI: 0.36 to 0.55) (Figure 4).

The intraradicular posts used in the included studies were prefabricated fiber (glass, carbon, quartz) and prefabricated metal (titanium) and cast post and core. A subgroup analysis was considered for the different types of posts. Teeth reconstructed with prefabricated glass fiber posts ($P < 0.0001$; RR: 0.54; CI: 0.40 to 0.73) or customizable fiberglass (EverStick) ($P = 0.0004$; RR: 0.66; CI: 0.52 to 0.83) had lower risks of failure compared to teeth that did not use posts. However, coronal restorations restored with prefabricated metal posts ($P = 0.67$; RR: 1.19; CI: 0.54 to 2.64) or cast metal posts ($P = 0.66$; RR: 0.84; CI: 0.39 to 1.82), did not show difference in the incidence of failures compared to the groups that did not receive posts.

Regarding the bias risk analysis, of the selected studies, four were considered high risk [1,2,34,37], with two of the studies due to observed failures in the randomization and patient allocation process [1,2], and two of the studies due to missing data [34,37]. Additionally, four studies [31,33,35,39] had some concerns related to the randomization and allocation process and were classified as having some concerns. The remaining studies had an overall low risk of bias (Figure 6).

The analysis of the certainty of evidence for the evaluated outcome showed low certainty of evidence, even with the inclusion of randomized clinical trials. Factors considered for downgrading the levels of certainty were related to the risk of bias and indirect evidence. The justification for downgrading the levels and the description of the certainty of evidence are detailed in Table 2.

4. DISCUSSION

The hypothesis that there would be no difference in the failure rates of ETTs with or without the use of posts was rejected since restorations of ETTs with intraradicular posts showed less failure rates. These results are consistent with results reported by Ferrari et al. [36], in a 2-year clinical trial which more failures were observed in the group that did not use posts, significantly contributing to the greater survival of these elements. However, Kramer et al. [40], did not find the same results. They evaluated 195 ETTs with posts over 6.5 years, and the survival rate was 83%, lower than that found by Wierichs et al. [42], who reported a survival rate in teeth that did not use retainers of 94% over 10 years of follow-up.

This difference can be justified by the fact that the high failure rate of teeth without posts is often considered reparable failures, such as crown or core fracture, secondary caries, or failure of endodontic treatment, which, after reparation, keeps the tooth in function [36]. Additionally, avoiding intraradicular posts in ETTs allows for the preservation of healthy dental structure [9], and their use should be considered when extensive coronal destruction is detected, as in such cases, they can reduce the risk of failures [2,33,34,37].

However, in the sub-analysis specifically evaluating irreparable root fractures, a favorable outcome for the use of intraradicular posts was still observed. For both groups, root fractures were more common when the coronal structure was compromised. This fact agrees with a previous systematic review that reported which ferrule and maintaining cavity walls are the most important factors to the survival of ETT. However, the same study reported no positive effect of post-placement in restorations of ETT [43]. In our systematic review, the restorations without posts presented higher failures and increased significantly as the remaining coronal structure decreased. This can be justified by the greater difficulty of adhesion to intraradicular dentin by restorative materials compared to coronal dentin [36], and the presence of a 2 mm ferrule may reinforce the cervical part of the root, where most fractures occur [43]. Cagidiaco et al. [35] reported root fractures only when the coronal structure was reduced to one or no coronal wall remaining, while Ferrari et al. [32] reported fractures occurring with two or fewer coronal walls remaining. This point was reported by another study, that reported increased failures due to the reduction of coronal walls [13]. This underscores the importance and necessity of preserving the remaining tooth structure. Therefore, one of the limitations of this review was the inability to conduct a specific analysis considering the amount of remaining tooth structure reported by the studies. Often, the authors did not highlight these issues or did not make it clear how failures were related to the amount of remaining structure. Thus, future studies considering these characteristics are recommended.

Many of the studies included in this review primarily used premolars. According to Ferrari et al. [13], the incidence of failures in premolars can be explained by the role they play in occlusal movements. During group disocclusion, in lateral movements, premolars, along with canines, which are single-rooted teeth with longer roots and a greater distance from the fulcrum during mandibular movement, end up being more susceptible to lateral forces and are consequently more prone to crown and/or retainer fractures and dislodgments. While molars were also included in this study, the failures were specifically concentrated in the premolar group. The same result was found by Bitter et al. [33], who recorded higher failure rates in premolars and molars that did not receive retainers and in anterior teeth when they did receive retainers.

Other facts that contribute to the incidence of failure rate should be considered the materials restorations (direct or indirect). Only one study included amalgam besides resin composite for direct restorations. Fractures also occurred more frequently in the amalgam group, despite the teeth included in this study having minimal loss of coronal structure. This can be explained by the fact that amalgam is a rigid material that requires more removal of healthy coronal structure for its placement, leading to a higher incidence of fractures compared to the adhesive materials used in the retainer group [37]. However, no difference in the use or non-use of posts was observed in this study [37]. This fact is in agreement with our analysis since no difference between evaluated groups was observed for direct restorations.

This similarity could be justified by the limited number of studies that allowed inclusion for this sub-analysis, as well as the fact that all the studies included had teeth with more than 25% preserved dental structure, which could, to some extent, improve the adhesive characteristics of the restoration even without a retainer. Scotti et al. [44] did not find a significant difference in failures of teeth restored without posts with either direct or indirect restorations. It is important to note that only two of the studies included in the sub-analysis were divided specifically into the results of the failures by the type of direct and indirect restoration. For Fokkinga et al. [34], there was no significant difference for direct restorations with or without, justifying that most failures, mostly due to secondary caries at the restoration level, can be repaired, postponing the use of partial or full crowns, and preserving remaining coronal that may have a positive impact on future reconstructions. Creugers et al., 2005, also reported difficulty in analyzing the use of post and the type of tooth due to the small number of failures found.

Clinical studies comparing direct restorations without posts in ETT are scarce, and they often report small sample sizes with limited significance. Suksaphar et al. [45], in a systematic review of direct and indirect restorations in non-vital teeth, did not find significant differences in fracture rates in cases of moderate loss of coronal structure. Similarly, Shu et al. [46], recommended indirect restorations, especially in teeth with extensive coronal destruction. Both recommend clinical trials with longer follow-up times, samples including all types of teeth, similar coronal destruction, randomization, and allocation of the evaluated groups to generate more reliable results.

The results found in this systematic review reported that the use of posts for indirect restorations was more favorable in reducing failure rates. However, this could again be related to the coronal remnant, as failures were higher in groups with reduced coronal structure. Fokkinga et al., 2007, found similar results for the survival of teeth with or without post with an indirect restoration and with up to 50% of the structure preserved. Based on these findings, they do not recommend the use of intraradicular posts in non-vital teeth with preserved dental structures. Therefore, the results should be interpreted with caution, and the clinicians should consider the individual characteristics of teeth to indicate better alternative restorations.

When specifically evaluating the different types of retainers, the failure rates of glass fiber posts (prefabricated or customizable) followed the overall failure rates, favoring their use. One of the factors related to this may be the proximity of the mechanical values of glass fiber posts to the dental structure [47], which could, to some extent, reduce stress concentration along the structure and consequently reduce the possibility of failures [48]. However, the use of glass fiber posts in reducing failure rates, especially root fractures, is controversial. Posts with a low modulus of elasticity tend to debond, which can be considered a mechanism to protect the remaining dental structure, preventing root fracture occurrence [25,49]. According to Soares et al. [50], although glass fiber posts showed similar failure rates to cast metal posts, the group of metal retainers had a higher probability of catastrophic failures, indicating a possible early tooth loss. These findings were corroborated by the in vitro study by Barcellos et al. [51], which highlighted a higher incidence of catastrophic failures, especially for teeth with enlarged root canals.

In the findings of this study, no differences were found regarding the use or non-use of metal posts (cast or prefabricated). However, Cloet et al., 2017, and Fokkinga et al., 2007, do not correlate the use of cast post and cores with an increase in irreparable failures; both reported the failures to the amount of coronal remnant. Therefore, it is important to emphasize that a limited number of studies participated in these sub-analyses, and this can be considered a limitation for a conclusive assessment of the results found.

Despite a considerable number of included RCT studies, there are other limitations to consider, such as small samples of anterior teeth, a significant reduction in the number of ETT without retainers (less than half of the group with retainers), no reporting on the type of cementation used, different inclusion criteria in the studies, failures in patient allocation, and differences regarding the procedure and the amount of coronal remnant. All these factors can be considered for the high heterogeneity of collected data, as well as the impossibility of some analyses. In addition, a low certainty of evidence was observed. Therefore, the results found by this study should be interpreted with caution, and more well-described randomized clinical trials are recommended for a reassessment of these findings including the previously parameters mentioned.

5. CONCLUSION

Given the limitations of this systematic review and meta-analysis, the conclusions are as follows:

- The use of intraradicular retainers can be considered a favorable alternative for the rehabilitation of ETT as it does not increase the chances of failure or the possibility of root fractures.
- In the case of direct restorations, the use or non-use of intraradicular retainers can be considered for dental reconstruction.
- When choosing to use intraradicular retainers, fiber posts showed lower risks of failure compared to other types of retainers.

6. REFERENCES

[1] Zicari F, Van Meerbeek B, Debels E, Lesaffre E, Naert I. An up to 3-Year Controlled Clinical Trial Comparing the Outcome of Glass Fiber Posts and Composite Cores with Gold Alloy-Based Posts and Cores for the Restoration of Endodontically Treated Teeth. Int J Prosthodont. 2011;24(4):363-72.

[2] Cloet E, Debels E, Naert I. Controlled Clinical Trial on the Outcome of Glass Fiber Composite Cores Versus Wrought Posts and Cast Cores for the Restoration of Endodontically Treated Teeth: A 5-Year Follow-up Study. Int J Prosthodont. 2017;30(1):71-79. doi:10.11607/ijp.4861

[3] Akbari MAH, Jamali H, Gholami AA, Majidinia S. One-Year Clinical Comparison of Survival of Endodontically Treated Premolar Restored with Different Direct Restoration Technique: A Prospective Cohort Study. Raz Int. J. Med. Inpress. 2016;4,e39800. http://dx.doi.org/10.17795/rijm39800

[4] Tang W, Wu Y, Smales RJ. Identifying and reducing risks for potential fractures in

endodontically treated teeth. J Endod. 2010;36(4):609-67. doi:10.1016/j.joen.2009.12.002

[5] Salameh Z, Ounsi HF, Aboushelib MN, Sadig W, Ferrari M. Fracture resistance and failure patterns of endodontically treated mandibular molars with and without glass fiber post in combination with a zirconia-ceramic crown. J Dent. 2008;36(7):513-19. doi:10.1016/j.jdent.2008.03.014

[6] Martins MD, Junqueira RB, de Carvalho RF, Lacerda MFLS, Faé DS, Lemos CAA. Is a fiber post better than a metal post for the restoration of endodontically treated teeth? A systematic review and meta-analysis. J Dent. 2021;112:103750. doi:10.1016/j.jdent.2021.103750

[7] Salvi GE, Siegrist Guldener BE, Amstad T, Joss A, Lang NP. Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting. Int Endod J. 2007;40(3):209-15. doi:10.1111/j.1365-2591.2007.01218.x

[8] Jurema AB, Bresciani E, Caneppele TMF. Influence of glass fiber posts on the fracture susceptibility of endodontically treated maxillary anterior teeth with direct veneers: Preliminary results of a randomized clinical trial. J Esthet Restor Dent. 2021;33(4):613-20. doi:10.1111/jerd.12669

[9] Balkenhol M, Wöstmann B, Rein C, Ferger P. Survival time of cast post and cores: a 10-year retrospective study. J Dent. 2007;35(1):50-8. doi:10.1016/j.jdent.2006.04.004

[10] Garoushi S, Vallittu PK, Watts DC, Lassila LV. Polymerization shrinkage of experimental short glass fiber-reinforced composite with semi-inter penetrating polymer network matrix. Dent Mater. 2008;24(2):211-15. doi:10.1016/j.dental.2007.04.001

[11] Bhuva B, Giovarruscio M, Rahim N, Bitter K, Mannocci F. The restoration of root filled teeth: a review of the clinical literature. Int Endod J. 2021;54(4):509-35.

[12] Pontoriero DIK, Grandini S, Spagnuolo G, et al. Clinical Outcomes of Endodontic Treatments and Restorations with and without Posts Up to 18 Years. J Clin Med. 2021;10(5):908. Published 2021 Feb 25. doi:10.3390/jcm10050908

[13] Ferrari M, Ferrari Cagidiaco E, Goracci C, et al. Posterior partial crowns out of lithium disilicate (LS2) with or without posts: A randomized controlled prospective clinical trial with a 3-year follow up. J Dent. 2019;83:12-7. doi:10.1016/j.jdent.2019.01.004

[14] Naumann M, Schmitter M, Krastl G. Postendodontic Restoration: Endodontic Post-

and-Core or No Post At All?. J Adhes Dent. 2018;20(1):19-24. doi:10.3290/j.jad.a39961

[15] Creugers NH, Mentink AG, Käyser AF. An analysis of durability data on post and core restorations. J Dent. 1993;21(5):281-4. doi:10.1016/0300-5712(93)90108-3

[16] Heydecke G, Peters MC. The restoration of endodontically treated, single-rooted teeth with cast or direct posts and cores: a systematic review. J Prosthet Dent. 2002;87(4):380-6. doi:10.1067/mpr.2002.123848

[17] Bolla M, Muller-Bolla M, Borg C, Lupi-Pegurier L, Laplanche O, Leforestier E. Root canal posts for the restoration of root filled teeth. Cochrane Database Syst Rev. 2007;(1):CD004623. Published 2007 Jan 24. doi:10.1002/14651858.CD004623.pub2

[18] Al-Dabbagh RA. Survival and success of endocrowns: A systematic review and meta-analysis. J Prosthet Dent. 2021;125(3):415.e1-415.e9. doi:10.1016/j.prosdent.2020.01.011

[19] Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version\6.2 (updated February 2021). Cochrane, 2021. Available from www.training.cochrane.org/handbook.

[20] Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. Published 2021 Mar 29. doi:10.1136/bmj.n71

[21] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev. 2016;5(1):210. Published 2016 Dec 5. doi:10.1186/s13643-016-0384-4

[22] Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898. Published 2019 Aug 28. doi:10.1136/bmj.l4898

[23] Egger M, Smith GD, Phillips AN. Meta-analysis: principles and procedures. BMJ. 1997;315(7121):1533-1537. doi:10.1136/bmj.315.7121.1533

[24] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159-74.

[25] Cagidiaco MC, Radovic I, Simonetti M, Tay F, Ferrari M. Clinical performance of fiber post restorations in endodontically treated teeth: 2-year results. Int J Prosthodont. 2007;20(3):293-98.

[26] Mannocci F, Bertelli E, Sherriff M, Watson TF, Ford TR. Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. J Prosthet Dent. 2002;88(3):297-301. doi:10.1067/mpr.2002.128492

[27] Munaga S, Das A, Kaur T, Yaqoob A, Mokashi R, Ismail PM. Comparative Clinical Evaluation of Composite Overcast Gold Post and Core Buildups in Endodontically Treated Teeth. J Contemp Dent Pract. 2018;19(10):1273-7. Published 2018 Oct 1..

[28] Guldener KA, Lanzrein CL, Siegrist Guldener BE, Lang NP, Ramseier CA, Salvi GE. Long-term Clinical Outcomes of Endodontically Treated Teeth Restored with or without Fiber Post-retained Single-unit Restorations. J Endod. 2017;43(2):188-93. doi:10.1016/j.joen.2016.10.008

[29] Ma H, Shen L, Liu K, Su L. Hua Xi Kou Qiang Yi Xue Za Zhi. 2013;31(1):45-48.

[30] Li, Z., Gao, C., Xu, Y., & Xu, J. (2015). Hua xi kou qiang yi xue za zhi = Huaxi kouqiang yixue zazhi = West China journal of stomatology, 33(3), 263–266. https://doi.org/10.7518/hxkq.2015.03.010
2005;30(1):9-15.

[31] Karteva EG, Manchorova NA, Vladimirov SB, Keskinova DA. Clinical Assessment of Endodontically Treated Teeth, Restored with or without Radicular Posts. Folia Med (Plovdiv). 2018;60(2):291-9. doi:10.1515/folmed-2017-0098

[32] Ferrari M, Vichi A, Fadda GM, et al. A randomized controlled trial of endodontically treated and restored premolars. J Dent Res. 2012;91(7 Suppl):72S-8S. doi:10.1177/0022034512447949

[33] Bitter K, Noetzel J, Stamm O, et al. Randomized clinical trial comparing the effects of post placement on failure rate of postendodontic restorations: preliminary results of a mean period of 32 months. J Endod. 2009;35(11):1477-82. doi:10.1016/j.joen.2009.07.026

[34] Fokkinga WA, Kreulen CM, Bronkhorst EM, Creugers NH. Composite resin core-crown reconstructions: an up to 17-year follow-up of a controlled clinical trial. Int J Prosthodont. 2008;21(2):109-115.

[35] Cagidiaco MC, García-Godoy F, Vichi A, Grandini S, Goracci C, Ferrari M. Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars. Am J Dent. 2008;21(3):179-84.

[36] Ferrari M, Cagidiaco MC, Grandini S, De Sanctis M, Goracci C. Post placement

affects survival of endodontically treated premolars. J Dent Res. 2007;86(8):729-34. doi:10.1177/154405910708600808

[37] Fokkinga WA, Kreulen CM, Bronkhorst EM, Creugers NH. Up to 17-year controlled clinical study on post-and-cores and covering crowns. J Dent. 2007;35(10):778-86. doi:10.1016/j.jdent.2007.07.006

[38] Creugers NH, Mentink AG, Fokkinga WA, Kreulen CM. 5-year follow-up of a prospective clinical study on various types of core restorations. Int J Prosthodont. 2005;18(1):34-9.

[39] Mannocci F, Qualtrough AJ, Worthington HV, Watson TF, Pitt Ford TR. Randomized clinical comparison of endodontically treated teeth restored with amalgam or with fiber posts and resin composite: five-year results. Oper Dent.

[40] Kramer EJ, Meyer-Lueckel H, Wolf TG, Schwendicke F, Naumann M, Wierichs RJ. Success and survival of post-restorations: six-year results of a prospective observational practice-based clinical study. Int Endod J. 2019;52(5):569-78. doi:10.1111/iej.13040

[42] Wierichs RJ, Kramer EJ, Wolf TG, Naumann M, Meyer-Lueckel H. Longevity of composite build-ups without posts-10-year results of a practice-based study. Clin Oral Investig. 2019;23(3):1435-42. doi:10.1007/s00784-018-2565-0

[43] Naumann M, Schmitter M, Frankenberger R, Krastl G. "Ferrule Comes First. Post Is Second!" Fake News and Alternative Facts? A Systematic Review. J Endod. 2018;44(2):212-9. doi:10.1016/j.joen.2017.09.020

[43] Bijelic J, Garoushi S, Vallittu PK, Lassila LV. Fracture load of tooth restored with fiber post and experimental short fiber composite. Open Dent J. 2011;5:58-65. Published 2011 Mar 29. doi:10.2174/1874210601105010058

[44] Scotti N, Coero Borga FA, Alovisi M, Rota R, Pasqualini D, Berutti E. Is fracture resistance of endodontically treated mandibular molars restored with indirect onlay composite restorations influenced by fibre post insertion?. J Dent. 2012;40(10):814-20. doi:10.1016/j.jdent.2012.06.005

[45] Suksaphar W, Banomyong D, Jirathanyanatt T, Ngoenwiwatkul Y. Survival rates against fracture of endodontically treated posterior teeth restored with full-coverage crowns or resin composite restorations: a systematic review. Restor Dent Endod. 2017;42(3):157-67. doi:10.5395/rde.2017.42.3.157

[46] Shu X, Mai QQ, Blatz M, Price R, Wang XD, Zhao K. Direct and Indirect

Restorations for Endodontically Treated Teeth: A Systematic Review and Meta-analysis, IAAD 2017 Consensus Conference Paper. J Adhes Dent. 2018;20(3):183-94. doi:10.3290/j.jad.a40762

[47] Franco EB, Lins do Valle A, Pompéia Fraga de Almeida AL, Rubo JH, Pereira JR. Fracture resistance of endodontically treated teeth restored with glass fiber posts of different lengths. J Prosthet Dent. 2014;111(1):30-4. doi:10.1016/j.prosdent.2013.09.013

[48] Marchionatti AME, Wandscher VF, Rippe MP, Kaizer OB, Valandro LF. Clinical performance and failure modes of pulpless teeth restored with posts: a systematic review. Braz Oral Res. 2017;31:e64. Published 2017 Jul 3. doi:10.1590/1807-3107BOR-2017.vol31.0064

[49] Bitter K, Kielbassa AM. Post-endodontic restorations with adhesively luted fiber-reinforced composite post systems: a review. Am J Dent. 2007;20(6):353-60.

[50] Soares CJ, Valdivia AD, da Silva GR, Santana FR, Menezes Mde S. Longitudinal clinical evaluation of post systems: a literature review. Braz Dent J. 2012;23(2):135-740. doi:10.1590/s0103-64402012000200008

[51] Barcellos RR, Correia DP, Farina AP, Mesquita MF, Ferraz CC, Cecchin D. Fracture resistance of endodontically treated teeth restored with intra-radicular post: the effects of post system and dentine thickness. J Biomech. 2013;46(15):2572-2577. doi:10.1016/j.jbiomech.2013.08.016

Figure 1. Flowchart of search strategy

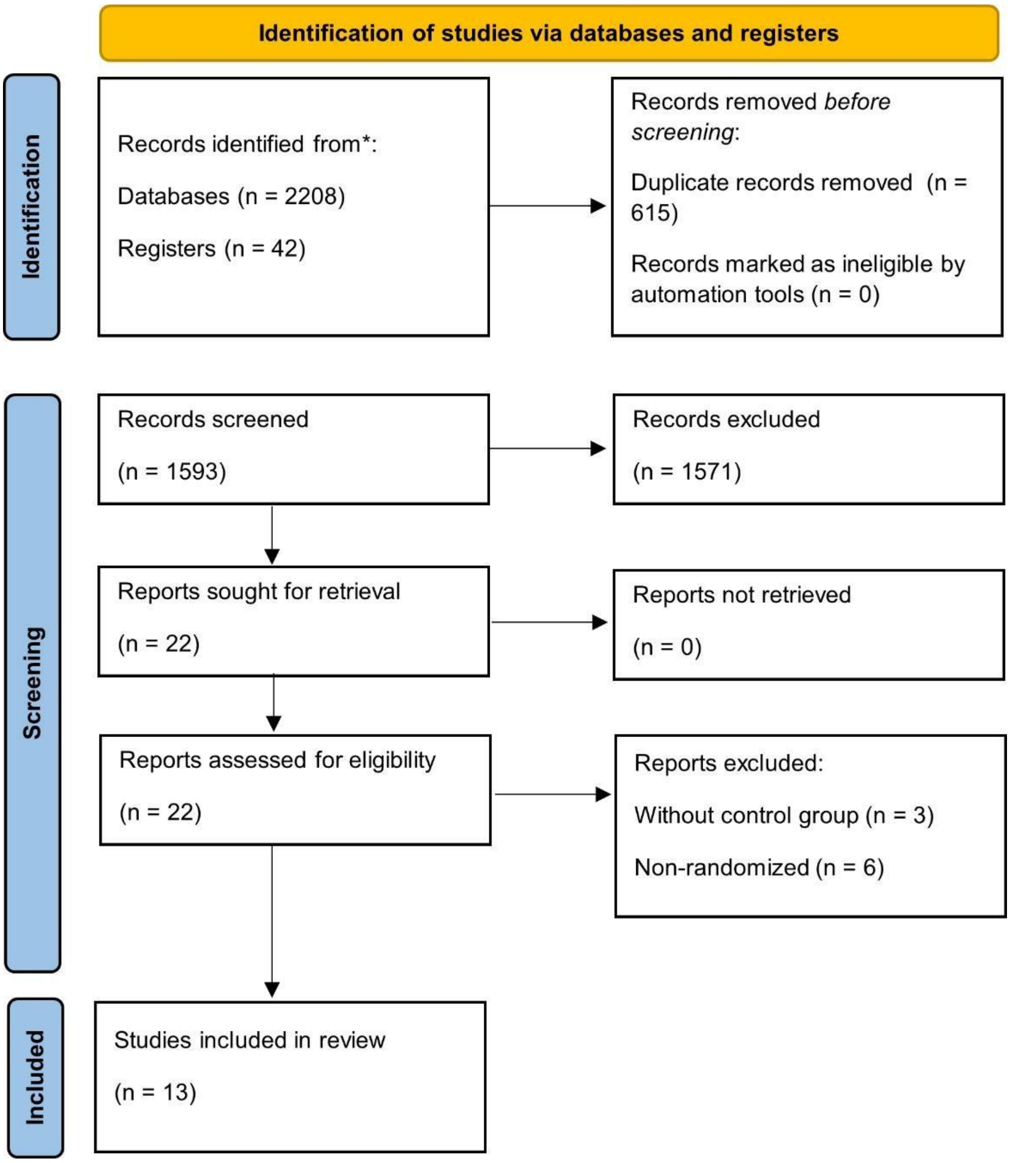

Figure 2. Forest plot of failure rates of ETT with or without posts.

Study or Subgroup	Post Events	Post Total	No Post Events	No Post Total	Weight	Risk Ratio M-H, Random, 95% CI
Bitter, 2009	3	61	6	57	3.9%	0.47 [0.12, 1.78]
Cagidiaco, 2008	39	240	45	120	18.6%	0.43 [0.30, 0.63]
Cloet, 2017	42	187	4	12	8.1%	0.67 [0.29, 1.57]
Creugers, 2005	13	277	2	42	3.4%	0.99 [0.23, 4.21]
Ferrari, 2007	9	120	36	120	10.6%	0.25 [0.13, 0.50]
Ferrari, 2012	65	209	63	107	22.1%	0.53 [0.41, 0.68]
Ferrari 2019	3	60	5	60	3.7%	0.60 [0.15, 2.40]
Fokkinga, 2007	53	268	7	39	10.1%	1.10 [0.54, 2.25]
Fokkinga, 2008	10	54	6	44	7.0%	1.36 [0.54, 3.44]
Jurema, 2021	3	25	4	25	3.7%	0.75 [0.19, 3.01]
Karteva, 2017	0	22	0	10		Not estimable
Manocci, 2005	10	97	9	100	7.9%	1.15 [0.49, 2.70]
Zicari, 2011	7	187	0	12	1.0%	1.04 [0.06, 17.18]
Total (95% CI)		**1807**		**748**	**100.0%**	**0.61 [0.46, 0.81]**
Total events	257		187			

Heterogeneity: Tau² = 0.08; Chi² = 18.19, df = 11 (P = 0.08); I² = 40%
Test for overall effect: Z = 3.38 (P = 0.0007)

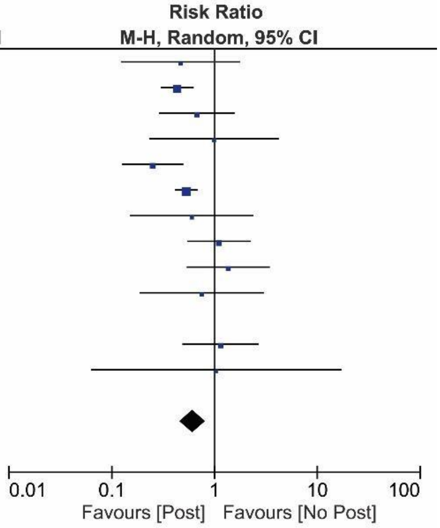

Figure 2. Forest plot of failure rates isolating root fracture of ETT with or without posts.

Study or Subgroup	Post Events	Post Total	No Post Events	No Post Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.4.1 Root Fracture						
Bitter, 2009	1	61	3	57	4.5%	0.31 [0.03, 2.91]
Cagidiaco, 2008	0	240	13	120	26.1%	0.02 [0.00, 0.31]
Creugers, 2005	4	277	1	42	2.5%	0.61 [0.07, 5.30]
Ferrari, 2007	0	120	9	120	13.8%	0.05 [0.00, 0.89]
Ferrari, 2012	4	209	16	107	30.7%	0.13 [0.04, 0.37]
Ferrari 2019	0	60	2	60	3.6%	0.20 [0.01, 4.08]
Fokkinga, 2007	5	268	2	39	5.1%	0.36 [0.07, 1.81]
Fokkinga, 2008	1	54	0	44	0.8%	2.45 [0.10, 58.80]
Jurema, 2021	0	25	1	25	2.2%	0.33 [0.01, 7.81]
Manocci, 2005	0	97	6	100	9.3%	0.08 [0.00, 1.39]
Zicari, 2011	2	187	0	12	1.4%	0.35 [0.02, 6.83]
Subtotal (95% CI)		**1598**		**726**	**100.0%**	**0.15 [0.08, 0.26]**
Total events	17		53			
Heterogeneity: Chi² = 9.81, df = 10 (P = 0.46); I² = 0%						
Test for overall effect: Z = 6.38 (P < 0.00001)						
1.4.2 Failures Rates						
Bitter, 2009	2	61	3	57	1.9%	0.62 [0.11, 3.59]
Cagidiaco, 2008	39	240	32	120	26.4%	0.61 [0.40, 0.92]
Creugers, 2005	9	277	1	42	1.1%	1.36 [0.18, 10.50]
Ferrari, 2007	9	120	27	120	16.7%	0.33 [0.16, 0.68]
Ferrari, 2012	61	209	47	107	38.4%	0.66 [0.49, 0.90]
Ferrari 2019	3	60	3	60	1.9%	1.00 [0.21, 4.76]
Fokkinga, 2007	48	268	5	39	5.4%	1.40 [0.59, 3.29]
Fokkinga, 2008	9	54	6	44	4.1%	1.22 [0.47, 3.17]
Jurema, 2021	3	25	3	25	1.9%	1.00 [0.22, 4.49]
Manocci, 2005	10	97	3	100	1.8%	3.44 [0.98, 12.11]
Zicari, 2011	5	187	0	12	0.6%	0.76 [0.04, 13.02]
Subtotal (95% CI)		**1598**		**726**	**100.0%**	**0.73 [0.59, 0.89]**
Total events	198		130			
Heterogeneity: Chi² = 15.61, df = 10 (P = 0.11); I² = 36%						
Test for overall effect: Z = 3.04 (P = 0.002)						

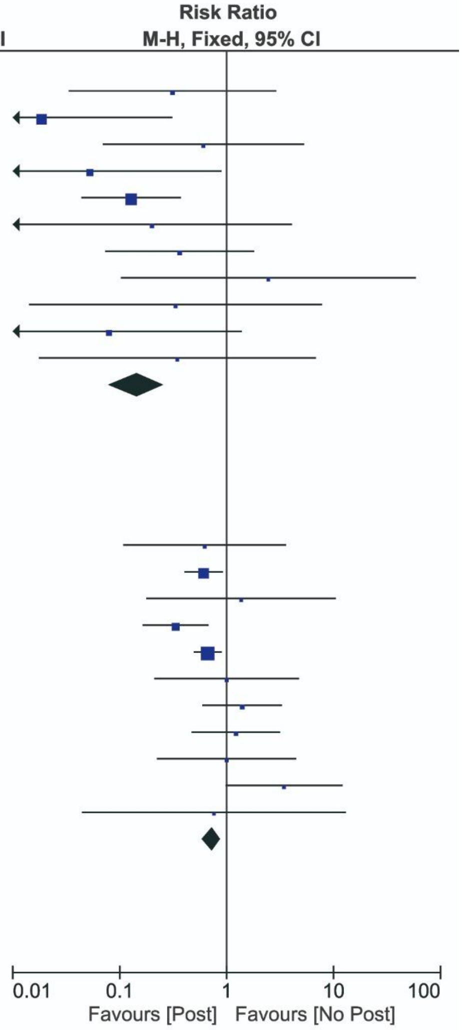

Figure 3. Forest plot of failure rates in subgroup analysis based on the type of restoration (direct or indirect) for ETT with or without posts.

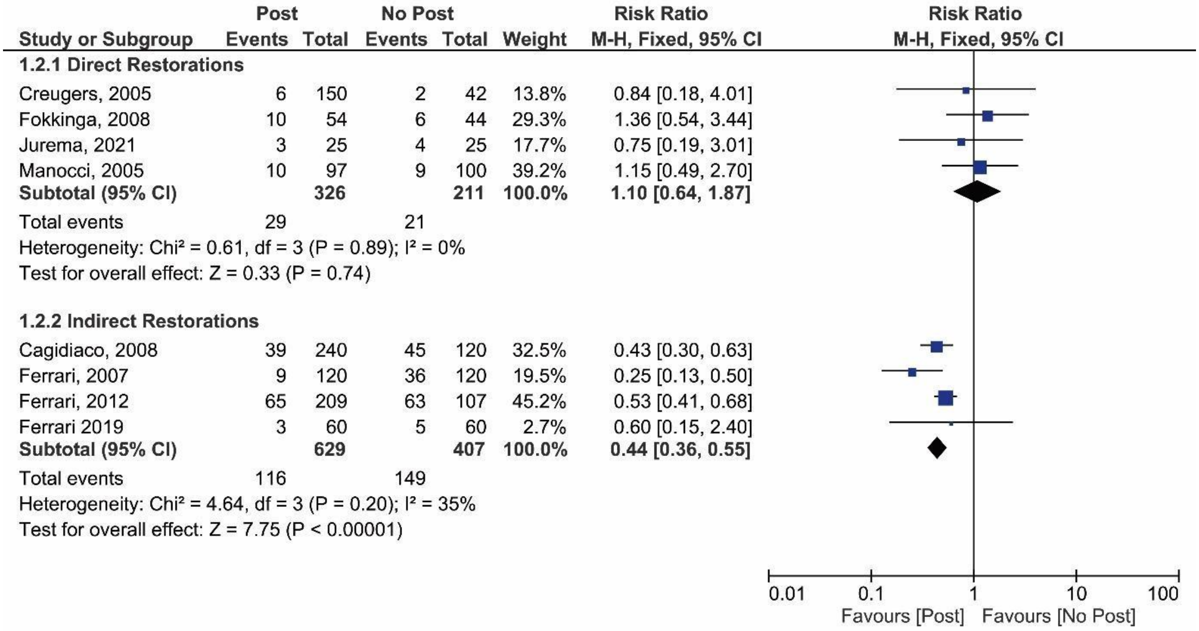

Figure 4. Forest plot of failure rates in subgroup analysis based on the type of post for ETT with or without posts.

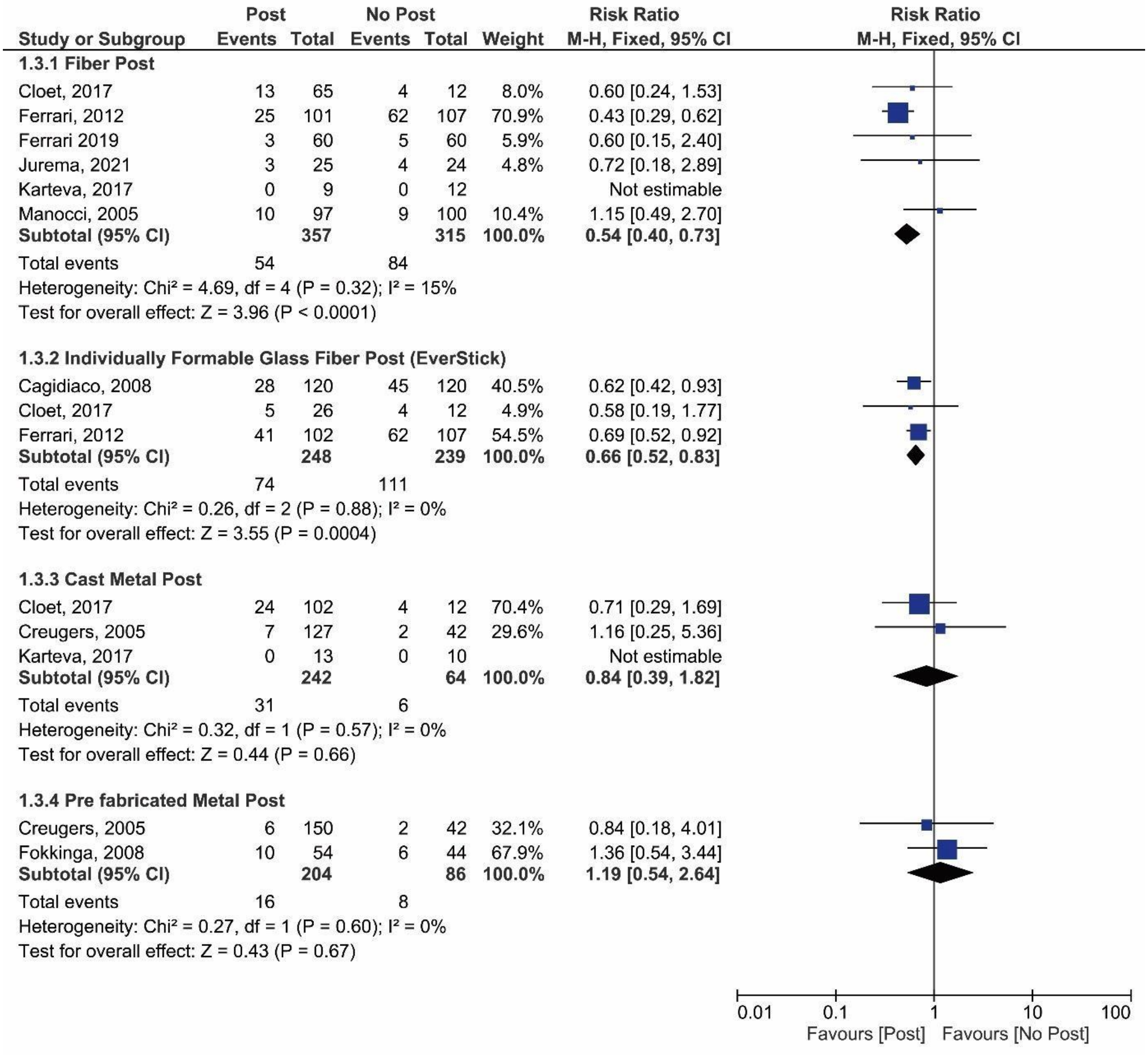

Figure 5. Risk of bias analysis for included RCT studies using RoB 2.0.

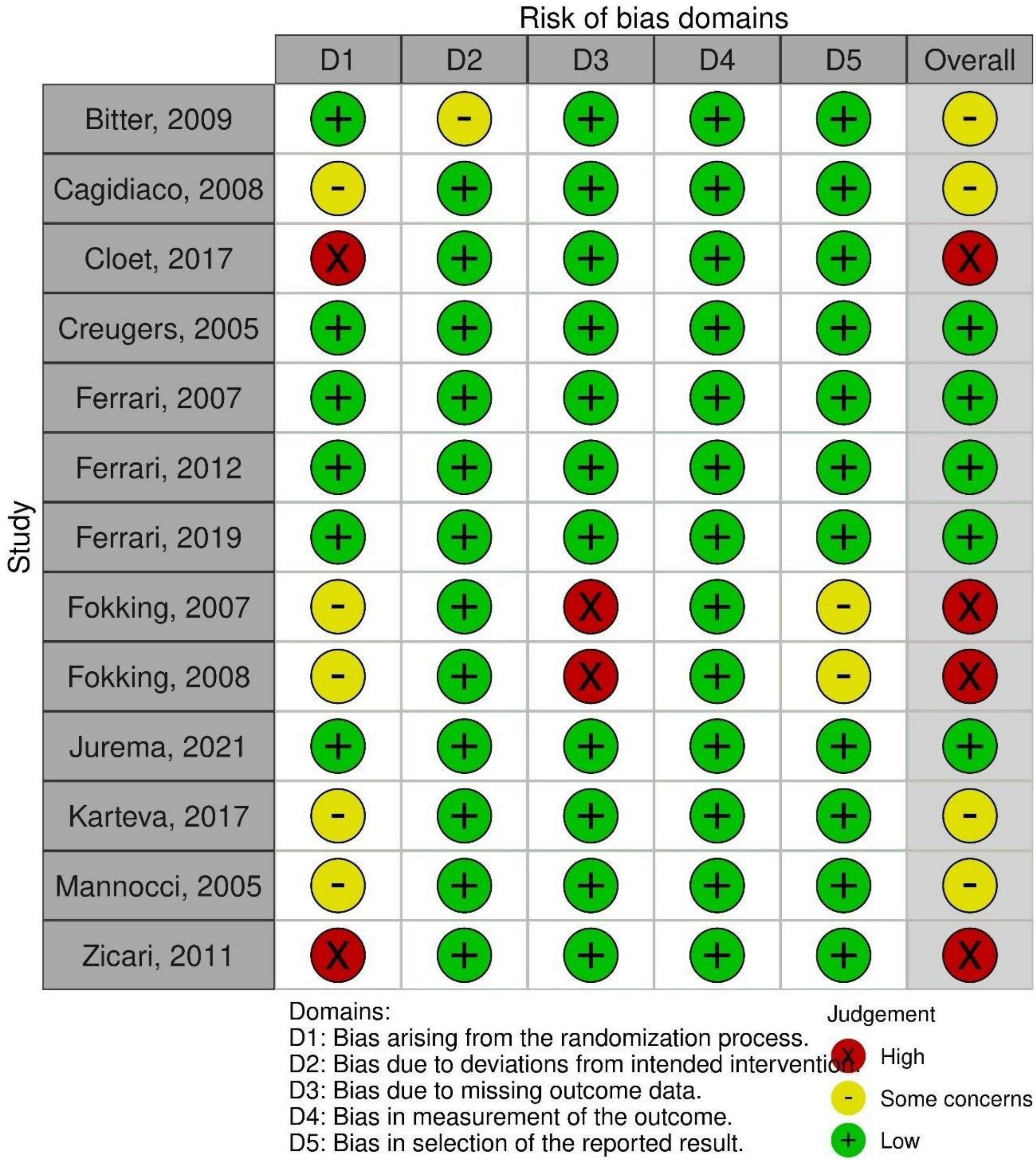

Table 1. Characteristics of Included Studies

Region Rehabilitated	Patient, n Gender	Mean age, years	Post Restoration	Region Rehabilitated	Commercial Brand (Post)	Remaining Coronal Walls	Crown Restora-tions	Follow-up, months	Failures No post	Failures Post	Survival/Success rates, (%) considering failures reported.
Jurema, 2021 [9]	50 Fe 25 Ma 25	44.08	25- FP 25- NP	50 A MX	(Rebilda Post; VOCO		CR	12 months	3 FCR 1 RF	3 FCR	Sucess- Post- 100% No Post- 96%
Ferrari, 2019 [13]	120 55 Ma 45 Fe	18-69	FP- 60 (30M, 30 PM) NP = 60 (30 M, 30 PM)	56- MX; 64- MD	GC Fiber Post; GC Corp., Tokyo, Japan)	Least 50% of remaining coronal structure	Lithium disilicate partial crowns	36 months	3 EF 2 RF	3 EF	1B- 93,3%/100%; 2A- 86,6%/93,3%; 2B- 96,6%/100% Sucess/ Survival
Cloet, 2017 [2]	143 67 Ma 76 Fe	47	CPC- 102 PMP- 65 PC- 26 CR- 12	A P	Parapost, Coltène-Whaledent EverStick, StickTech)	2 coronal walls	AC CR	84 months	FR- 1 FA- 3	FR- 10 CPC, 7 PMP, 3 PC FA- 14 CPC, 6 PMP, 2 PC	85.2% 91.5%
Karteva, 2017 [31]	22 12 Ma 10 Fe	18- 61	MP - 10 FP - 13 FRC - 9	PM	GC EverX Posterior, GC Europe).	loss of one or two proximal walls	CR	12 months	0	0	100%
Ferrari, 2012 [32]	360	NR	Customized post: 120 Pre fabricated post: 120 NP- 120	PM	DT Light Posts (RTD) EverStickb fibers	All the coronal waals, 3, 2, 1, ferrule and no ferrule	MC	72 months	FR: EF-15 CD-32 AF: RF-16	FR: EF-18; CD-15; DB-12; PF-16 AF: RF-4	No post 42.1%/85.9% Post: 68,95%/98,15%
Zicari, 2011 [1]	144 77 Fe 67 Ma	47	CPC: 102 CR 12 PMP: 65 PC: 26	NR	Parapost, Coltène-Whaledent EverStick, StickTech)	2 Coronal Walls	AC CR	37 months		FA- 2 RF FR- 1 EF 3 DB 1 PF	92,3% /93,7%

Bitter, 2009 [33]	90 42 Ma 49 Fe	48	Carbon Fiber Post	60 P (10 A, 13 PM, 37 M) 60 NP (15 A, 20 PM, 25 M)	DT Light Post (VDW)	2 or more Walls- 1 wall No wall	MC CR	(13.7) months st years	6 P 5 TL (3RF, 1SC, 1 CF) 1 NT (1FCR)	3 A 1 TL (1RF) 2 NT (1DB, 1 PF)	Survival 92% Post
Fokkinga, 2008 [34]	87 44 Fe 43 Ma	36 18- 65	Pre- fabricated	I/C-11; P-27; M-16= 54 I/C-8; P-27; M-9= 44	Radix or RS prefabricated post (Maillefer) Clearfil Core	> 75% of the circumferential dentin wall < 25% of the circumferential	CR	17 years	4 EX caries; 2 Ex Unknown reason Total=6 TE	4 Ex Caries;2 Ex Pal; 1 Ex fract; 1 Ex Unknown rea; 2 Ex Perio Total= 10 TE	"Tooth survival rate at year 17 was 79% ± 11%."
Cagidiaco, 2008 [35]	345	56	PMP PC	PM 20 /subgroup 360	DT Light Posts (RTD) EverStickb fibers	4, 3, 2, 1 wall, ferrule or No ferrule	MC	36 months	13 RF 32 CD	39 DB	Survival 76,7%. 62,5% No post PMP- 90% PC- 76,7%
Ferrari, 2007 [36]	210 93 Ma 117 Fe	18-76	FP- 20 each group	PM 128 MX 112 MD	DT Light Post posts -RTD	All the coronal waals, 3, 2, 1, ferrule and no ferrule	MC	24 months	36: 27 CD 9 RF	9 DB	Survival 81,3%; Post 92,5%; No Post 70%
Fokkinga, 2007 [37]	257 98 Ma 159 Fe	36 17-71	CPC- 118 PMP- 150 CR- 39 NP	NR	Cendres et Metaux prefabricated Radix or RS prefabricated post (Maillefer)	Trial 1= 196 substantial dentin height Trial 2= 111 minimal dentin height	MT MC	17 years	7	53	Survival Restoration- 71% at 80% Survival teeth- 83% at 92%
Creugers, 2005 [38]	249 97 Ma 152 Fe	17-71	Cast post Direct post	127 CPC (69- S 58- M 150 PMP (90- S ; 60- M NP- 42- S	Cendres et Métaux Radix or RS prefabricated post (Maillefer)	201 group S - “substantial dentin height” 118 group M - minimal dentin height	CR Alloy	60 months	1 RF 1 TL	7 CPC (4 RF, 3 DB) 6 PMP (2 RF, 3 DB, 1 TL)	Survival : substantial dentin height (98% ± 2%); minimal dentin height (93% ± 3%)
Mannocci, 2005 [39]	209 115 Fe 103 Ma	45	FP- 110 NP- 109	M PM	Composipost, RTD		CR Amalgam	60 months	6 RF 3 SC	10 SC	Survival (93,5%) Post 95% No post

RCT: Randomized Controlled Trial / Fe: Female / Ma: Male / FP: Fiber Post / CPC: Cast Post and Core / PMP: Prefabricated Metal Post / A: Anterior / P: Posterior / MP: Metal Post / MC: Metal Ceramic / AC: All Ceramic / MT: Metal / RF: Root fracture / CR: Composite Resin / DC: Direct Composite / DB: Debonding / EF: Endodontic Failure / SC: Secondary Caries / F: Fracture / TE: Tooth Extraction / AF: Absolute Failure / FR: Relative Failure / CD: Displacement Crown / PF: Post Fracture / PC: Customized Post / FC: Crown Fracture / TL: Tooth Loss / NT: No Tooth Loss / FCr: Fracture Composite / Mx: Maxila / Md: Mandible / FRC: Fiber Reinforced Composite / MP: Premolar / M: Molar / NP: No Post / EX: Extraction / FCR: Fracture Composite Resin / I: Incisor / C: Canine

Table 2. Analysis of the Certainty of Evidence

Assessment of the Certainty of Evidence							Patient Numbers		Effect		Confidence	Importance
Study Number	Study Design	Bias Risk	Inconsistency	Indirect Evidence	Imprecision	Other Considerations	Post	No Post	Relative (95% CI)	Absolut (95% CI)		
Failures												
13	RCT	grave[a]	no grave	grave[b]	no grave	none	257/1807 (14.2%)	187/748 (25%)	**RR 0.61** (0.46 to 0.81)	**98 less by 1.000** (from 135 down to 47)	⊕⊕◯◯ low	CRITICAL

CI: Confidence interval; **RR:** Risk ratio

Explanations
a. More than half of the included studies showed high or unclear overall risk of bias
b. There are many external factors that can have a direct influence on the results evaluated. Lack of relevant information for new sub-analyses extraction

Supplemental File 1. Search strategy in each electronic database

MEDLINE via PubMed	
#1	((((((("Tooth, Nonvital")) OR ("Devitalized Tooth")) OR ("Nonvital Tooth")) OR ("Nonvital Teeth")) OR ("Pulpless")) OR ("Endodontically Treated Teeth")) OR ("Endodontically Treated")
#2	((((((((((((((("Dental Restoration, Permanent")) OR ("Permanent Dental Restoration")) OR ("Permanent Dental Filling*")) OR ("Dental crown*")) OR ("Partial crown*")) OR ("Indirect Restoration*")) OR ("Direct Restoration*")) OR ("Build up")) OR ("Without post")) OR ("No post")) OR ("Post-free")) OR ("Postless")) OR ("Composite resin build*")) OR ("Direct veneer*")) OR ("Direct resin composite")) OR ("Direct composite restoration*")
#3	((((((((((((((("Post and Core Technique")) OR ("Post")) OR ("Post Technique")) OR ("Dental Dowel")) OR ("Dental Screw")) OR ("Post Retained")) OR ("Post Retention")) OR ("Prefabricated")) OR ("Customized Post")) OR ("Custom Post")) OR ("Quartz post")) OR ("Fiber Post")) OR ("Metal Post")) OR ("Carbon Post")) OR ("Cast Post")
#4	((((((("Survival")) OR ("Dental Restoration Failure*")) OR ("Success")) OR ("Complication*")) OR ("Fracture")) OR ("Failure*")) OR ("Longevity")
#5	#1 AND #2 AND #3 AND #4

Scopus	
#1	TITLE-ABS-KEY ("Tooth, Nonvital") OR TITLE-ABS-KEY ("Devitalized Tooth") OR TITLE-ABS-KEY ("Nonvital Tooth") OR TITLE-ABS-KEY ("Nonvital Teeth") OR TITLE-ABS-KEY ("Pulpless") OR TITLE-ABS-KEY ("Endodontically Treated Teeth") OR TITLE-ABS-KEY ("Endodontically Treated")
#2	TITLE-ABS-KEY ("Post and Core Technique") OR TITLE-ABS-KEY ("Post" OR "Post Technique") OR TITLE-ABS-KEY ("Dental dowel") OR TITLE-ABS-KEY ("Dental Screw") OR TITLE-ABS-KEY ("Post retained") OR TITLE-ABS-KEY ("Post retention") OR TITLE-ABS-KEY ("Prefabricated") OR TITLE-ABS-KEY ("Customized post") OR TITLE-ABS-KEY ("Custom post") OR TITLE-ABS-KEY ("Quartz post") OR TITLE-ABS-KEY ("Fiber post") OR TITLE-ABS-KEY ("Metal post") OR TITLE-ABS-KEY ("Carbon

	post") OR TITLE-ABS-KEY ("Cast post")
#3	TITLE-ABS-KEY ("Dental Restoration, Permanent") OR TITLE-ABS-KEY ("Permanent Dental Restoration") OR TITLE-ABS-KEY ("Permanent Dental Filling") OR TITLE-ABS-KEY ("Dental crown") OR TITLE-ABS-KEY ("Partial crown") OR TITLE-ABS-KEY ("Indirect Restoration") OR TITLE-ABS-KEY ("Direct Restoration") OR TITLE-ABS-KEY ("Build up") OR TITLE-ABS-KEY ("Without post") OR TITLE-ABS-KEY ("No post") OR TITLE-ABS-KEY ("Post-free") OR TITLE-ABS-KEY ("Postless") OR TITLE-ABS-KEY ("Composite resin build*") OR TITLE-ABS-KEY ("Direct veneer*") OR TITLE-ABS-KEY ("Direct resin composite") OR TITLE-ABS-KEY ("Direct composite restoration*")
#4	TITLE-ABS-KEY ("Survival") OR TITLE-ABS-KEY ("Dental Restoration Failure*") OR TITLE-ABS-KEY ("Success") OR TITLE-ABS-KEY ("Complication*") OR TITLE-ABS-KEY ("Fracture") OR TITLE-ABS-KEY ("Failure*") OR TITLE-ABS-KEY ("Longevity")
#5	#1 AND #2 AND #3 AND #4

Web of Science	
#1	((((((TS=(“Tooth, Nonvital”)) OR TS=(“Devitalized Tooth”)) OR TS=(“Nonvital Tooth")) OR TS=(“Nonvital Teeth”)) OR TS=(“Pulpless”)) OR TS=(“Endodontically Treated Teeth”)) OR TS=(“Endodontically Treated”)
#2	((((((((((((((TS=(“Post and Core Technique”)) OR TS=("Post")) OR TS=(“Post Technique”)) OR TS=(“Dental Dowel”)) OR TS=(“Dental Screw”)) OR TS=(“Post Retained”)) OR TS=(“Post Retention”)) OR TS=(“Prefabricated”)) OR TS=(“Customized Post”)) OR TS=(“Custom Post”)) OR TS=(“Quartz post”)) OR TS=(“Fiber Post”)) OR TS=(“Metal Post”)) OR TS=(“Carbon Post”)) OR TS=(“Cast Post”)

#3	((((((((((((((TS=("Dental Restoration, Permanent")) OR TS=("Permanent Dental Restoration")) OR TS=("Permanent Dental Filling*")) OR TS=("Dental crown*")) OR TS=("Partial crown*")) OR TS=("Indirect Restoration*")) OR TS=("Direct Restoration*")) OR TS=("Build up")) OR TS=("Without post")) OR TS=("No post")) OR TS=("Post-free")) OR TS=("Postless")) OR TS=("Composite resin build*")) OR TS=("Direct veneer*")) OR TS=("Direct resin composite")) OR TS=("Direct composite restoration*")
#4	((((((TS=("Survival")) OR TS=("Dental Restoration Failure*")) OR TS=("Success")) OR TS=("Complication*")) OR TS=("Fracture")) OR TS=("Failure*")) OR TS=("Longevity")
#5	#1 AND #2 AND #3 AND #4

Embase	
#1	'tooth, nonvital'/exp OR 'tooth, nonvital' OR 'devitalized tooth' OR 'nonvital tooth'/exp OR 'nonvital tooth' OR 'nonvital teeth' OR 'pulpless' OR 'endodontically treated teeth' OR 'endodontically treated'
#2	'post and core technique' OR 'post' OR 'post technique' OR 'dental dowel' OR 'dental screw' OR 'post retained' OR 'post retention' OR 'prefabricated' OR 'customized post' OR 'custom post' OR 'quartz post' OR 'fiber post' OR 'metal post' OR 'carbon post' OR 'cast post'
#3	'dental restoration, permanent' OR 'permanent dental restoration' OR 'permanent dental filling*' OR 'dental crown*' OR 'partial crown*' OR 'indirect restoration*' OR 'direct restoration*' OR 'build up' OR 'without post' OR 'no post' OR 'post-free' OR 'postless' OR 'composite resin build*' OR 'direct veneer*' OR 'direct resin composite' OR 'direct composite restoration*'
#4	'survival' OR 'dental restoration failure*' OR 'success' OR 'complication*' OR 'fracture' OR 'failure*' OR 'longevity'
#5	#1 AND #2 AND #3 AND #4

ProQuest
Noft ("Tooth, Nonvital" OR "Devitalized Tooth" OR "Nonvital Tooth" OR "Nonvital Teeth" OR "Pulpless" OR "Endodontically Treated Teeth" OR "Endodontically Treated") AND noft("Post and Core Technique" OR "Post" OR "Post Technique" OR "Dental dowel" OR "Dental Screw" OR "Post retained" OR "Post retention" OR "Prefabricated" OR "Customized post" OR "Custom post" OR "Quartz post" OR "Fiber post" OR "Metal post" OR "Carbon post" OR "Cast post") AND noft("Dental Restoration, Permanent" OR "Permanent Dental Restoration" OR "Permanent Dental Filling*" OR "Dental crown*" OR "Partial crown*" OR "Indirect Restoration*" OR "Direct Restoration*" OR "Build up" OR "Without post" OR "No post" OR "Post-free" OR "Postless" OR "Composite resin build*" OR "Direct veneer*" OR "Direct resin composite" OR "Direct composite restoration*") AND noft

2.2 ARTIGO CIENTÍFICO

Artigo científico em fase de execução e preparação paras normas e será submetido para publicação no periódico The Journal of Prosthetic Dentistry, qualis CAPES A1.

Digital workflow with intraoral scanners for root canal digitalization and post and core fabrication. A scoping review

ABSTRACT

Digital dentistry has been gaining increasing prominence, not only in dental laboratories but also in dental clinics. A fully digital workflow provides improved patient comfort, reduced working time, and precision. The aim of this scoping review was to map the available literature the use of intraoral scanners (IOS) and the influence of these models on the fabrication of post and core restorations for endodontically treated teeth in terms of accuracy, fit, and other parameters. The study protocol is available (https://osf.io/shu37). This scoping review followed the guidelines of the Joanna Briggs Institute and according to the checklist proposed by PRISMA-ScR. The research question was: Can IOS be used for scanning the root canal preparations for manufacturing of post and cores?'. Searches were conducted in the databases PubMed/MEDLINE, Web of Science, and Scopus, supplemented by a manual search of reference lists and gray literature (Google Scholar and ProQuest), up to August 2023. The searches yielded a total of 455 studies, and after screening, 15 studies were included for mapping. Based on the collected data, 7 IOS devices were evaluated for reading root canals. The IOS devices were compared with each other, as well as with laboratory scanners, micro-CT, radiographic, and/or clinical assessment, to determine accuracy, precision, internal and marginal fit, bond strength, and retention, among other factors. The fully digital workflow with IOS appears to be a promising alternative for the rehabilitation of endodontically treated teeth. However, the use of IOS for scanning of the root canal preparation requires improvements because some factors such as canal depth, the presence of a scan post, and the type of scanner used can influence and directly affect the accuracy values of the scan, and consequently, the fit of the future post inside the root canal. Therefore, future standardized clinical studies are recommended for better evidence of the highlighted factors.

Keywords: intraradicular retainer, scanner, digital scanning."

1. INTRODUCTION

The loss of dental structure due to carious processes, trauma, or during access to root canals can reduce the teeth's ability to withstand stresses (Akbari et al., 2016, Tang et al., 2010). Therefore, intraradicular posts are widely used to provide support for restorative materials in the coronal reconstructions of teeth with extensive coronal destruction (Morgano et al., 2004).

Various types of posts are used, such as metal and fiber posts (Martins et al., 2021; Salvi et al., 2007). Over the years, with the advent of the digital era in dentistry, milled posts have become an alternative option (Liu et al., 2019). A more precisely fitted post within the canal (Grandini et al., 2005) reduces the cement layer, the risk of failures (Balkenhol et al., 2007), and enhances the retention and fracture resistance of endodontically treated teeth (Bittner et al., 2010; da Costa et al., 2017; Tsintsadze et al., 2017)

The Computer-Aided Design and Manufacturing (CAD-CAM) system has made it possible to mill structures, streamlining laboratory processes (Kihara et al., 2019) and enabling faster and more precise manufacturing of a single piece with better internal adaptation to the root canal (Perucelli et al., 2020), reducing patient discomfort and clinical/laboratory times (Vinothkumar et al., 2011).

The main use of a scanner in the manufacture of intraradicular posts is through the generation of images by indirect technique, which consists of the digitalization of molding of the root canal with different materials (acrylic resins with low contraction or elastomeric materials) and milling with different materials. Intraoral scanners (IOS) are not traditionally used for direct digitalization of the root canals, and this use is quite challenging for dental optical scanners (Dupagne, 2023). However, with technological advancements, studies have started to assess the use of intraoral scanners for direct scanning of the root canal, as they can offer greater accuracy, precision, patient comfort, and a faster workflow, which are undeniable advantages for the use of IOS (Gurpinar, 2020). The currently available IOS on the market have various characteristics, including scanning modes, light sources used, type of generated image, scan output format, and utilization of some dispositive such as scan posts or products to coat the canal during scanning (Alzahrani et al., 2020). Each of these characteristics can influence the accuracy of scans, also considering the experience of the IOS operator (Elter et al., 2023). With the increasing availability of new IOS, and the diversity of forms of use, it is necessary to identify those that can offer better possibilities for scanning root canals. Therefore, the aim of this study was to identify through a scoping review, the mapping of literature to find scientific information about the use of IOS for scanning root canals for manufacturing of post and core restorations.

2. MATERIALS AND METHODS

The protocol for this study was based on the structure proposed by Peters et al, 2020, according to the Joana Brigs Institute. It also complies with the checklist proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews - PRISMA-SCR (Tricco et al, 2018).

The methodological development protocol for this scoping review has been registered on the Open Science Framework and can be accessed via the following link: https://osf.io/shu37.

The research question designed for the literature mapping was: “Can IOS be used for scanning the root canal preparations for manufacturing of posts and cores?”. The searches were conducted in three databases (PubMed/MEDLINE, Web of

Science, and Scopus) using the specified strategy below (Table 1). Two reviewers (J.S.J and C.A.A.L.) independently conducted the searches after exporting the results from the databases into the reference manager Rayyan QCRI. These searches were also complemented by a manual search in the reference lists and gray literature (Google Scholar and ProQuest). The first searches took place in September 2022, being updated in August 2023.

Table 1. Search strategies used for the included databases.

PubMed/MEDLINE ("tooth, nonvital"[MeSH Terms] OR "tooth nonvital"[All Fields] OR "Nonvital"[All Fields] OR "Devitalized"[All Fields] OR "Pulpless"[All Fields] OR "Endodontically treated"[All Fields]) AND ("Post and Core Technique"[MeSH Terms] OR "Post and Core Technique"[All Fields] OR "Post"[All Fields] OR "Fiber post"[All Fields] OR "Metal post"[All Fields] OR "Cast post"[All Fields] OR "Dowel"[All Fields]) AND ("Computer-Aided Design"[MeSH Terms] OR "Computer-Aided Design"[All Fields] OR "CAD"[All Fields] OR "Intraoral scanning"[All Fields] OR "Intraoral scanner"[All Fields] OR "Intraoral scan"[All Fields] OR "Digital impression"[All Fields] OR "Digital workflow"[All Fields])
WEB OF SCIENCE ALL=("tooth, nonvital" OR "Nonvital" OR "Devitalized" OR "Pulpless" OR "Endodontically treated") AND ALL=("Post and Core Technique" OR "Post" OR "Fiber post" OR "Metal post" OR "Cast post" OR "Dowel") AND ALL=("Computer-Aided Design" OR "CAD" OR "Intraoral scanning" OR "Intraoral scanner" OR "Intraoral scan" OR "Digital impression" OR "Digital workflow")
SCOPUS TITLE-ABS-KEY (("tooth, nonvital" OR "nonvital" OR "devitalized" OR "pulpless" OR "endodontically treated")) AND (TITLE-ABS-KEY ("post and core technique" OR "post" OR "fiber post" OR "metal post" OR "cast post" OR "dowel")) AND (TITLE-ABS-KEY ("computer-aided design" OR "cad" OR "intraoral scanning" OR "intraoral scanner" OR "intraoral scan" OR "digital impression" OR "digital workflow")

All types of studies available in the literature (in vitro, case reports, technique reports, case series, clinical trials) that evaluated the use of IOS for scanning the root canal were considered. All outcomes assessed by the studies were considered for inclusion in this scoping review. No restrictions were imposed regarding the language or publication period. Studies that evaluated only the hybrid scanning process (combined with conventional methods), whether using IOS or EOS, without including a group that performed direct scanning of the root canal with IOS in digital workflow, were excluded. In addition, reviews and editorials were also excluded. In cases where articles were not found, contact was made via email or ResearchGate to obtain the work.

The selected articles were tabulated by one author (J.S.J.) using Microsoft Excel 2010 (Office 10) through a standardized pilot data extraction form. The information to be collected was defined by two reviewers through consensus. Data from the articles were extracted, considering the following topics: Author/year of publication, study type, intraoral scanner evaluated, comparison method, assessed characteristic, scanning techniques, and main conclusions. The data were transferred to a table with the intention of enabling result synthesis, individualizing, and comparing the variables used by the studies for mapping. A second author (C.A.A.L) was responsible for verifying all extracted data.

The analysis of the articles was conducted individually, taking into consideration the findings reported by the studies. Therefore, the data found were tabulated, and a descriptive synthesis of the main findings was performed regarding the types of studies involved, the group of teeth evaluated, the types of scanners used in the present studies (whether for the comparative group or control groups), indicating which studies considered a comparison and what which control was involved. It was also considered whether the study involved used any artifice to allow digitization (e.g. scan posts or similar), the evaluation of the outcomes by the studies, and finally the results found, with the main recommendations by the included studies

3. RESULTS

Figure 1 shows the flowchart of the study selection process. The database search retrieved 455 articles. After duplicate records removed, 296 studies were left for selection based on title and abstract. Out of these, 246 articles were excluded for not meeting the pre-established inclusion criteria, leaving 50 articles for full-text reading. After reading the full text, 35 articles were excluded because they used only laboratory scanners, others because they only scanned the impression, and others because they made the post models based on computed tomography and/or microCT. A total of 15 studies were included for mapping (Table 2).

Figure 1. Flowchart of search strategy

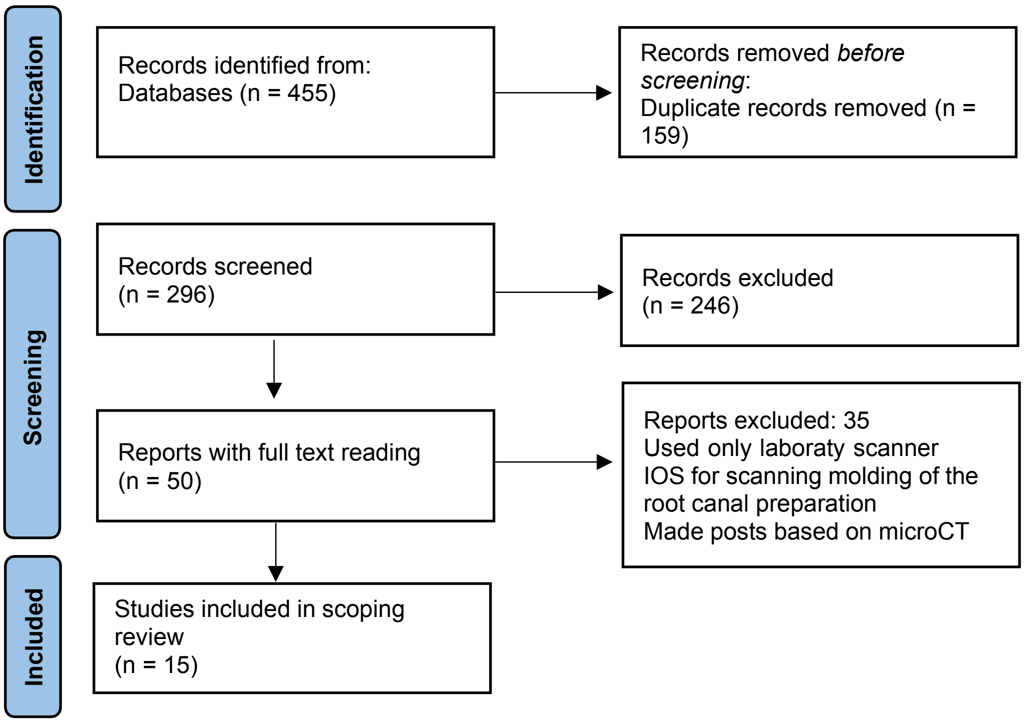

Table 2. Characteristics of the included studies

Author/year of publication	Study type	Tooth group	Groups Assessed	Artifice with IOS	Analysis type	Results found	Recommendations
Pinto et al. 2017	*In Vitro*	Premolars Humans	IOS (TRIOS - 3Shape) Indirect Technique Light Silicone	No	Depth Reading and Scanning Quality	- Significant Discrepancies Between Digital Scanning and Traditional Methods	The use of IOS for reading intraradicular space is not yet reliable, as there are limitations in reading deeper areas, due to the light beam not reaching these locations.
Hendy et al. 2018	*In Vitro*	Human premolars	IOS (TRIOS - 3Shape) Direct Technique (Acrylic Resin) Hybrid Indirect Technique (Light Silicone + Laboratory Scanner [D700 3-Shape])	With and Without Scan posts (CSO.90 – 3Shape)	Retention Accuracy (Apical Gap)	- Direct technique yields better retention values and smaller apical gaps. - Fully digital is superior to Hybrid Indirect for retention and apical gap.	Fully digital and semi-digital core and post manufacturing techniques cannot be recommended as an alternative to the conventional technique.
Kanduti et al. 2019	*In Vitro*	Upper Central Incisors Human	IOS (TRIOS - 3Shape) Direct Technique Acrylic Resin	Scan posts (1.7 APL – 3Shape)	Accuracy of adaptation (volume, area, and post distance – µCT))	- Smaller volume values for the direct technique group. - Greater accuracy in the apical regions was observed for the direct technique compared to the digital technique, but no difference was observed in the cervical region.	Digital scanning of intraradicular preparations provided similar accuracy to the conventional technique in the cervical region, which can be considered a more crucial area for good retention and fracture resistance.
Moustapha et al. 2019	*In Vitro*	Upper Central Incisors Mannequin (Typodont)	IOS (TRIOS - 3Shape) Hybrid Technique ([1] Acrylic resin and [2] Light Silicone + Laboratory Scanner [Imetric])	Scan posts	Internal and marginal adaptation	Less cementation space for the fully digital group compared to the hybrids (regardless of the scanned mold).	The complete digital workflow exhibits better adaptation compared to hybrid digital techniques. The hybrid technique introduces more variables that can interfere with accuracy.
Atia et al. 2020	*In Vitro*	Upper Central Incisors Human	IOS (CEREC Primescan)	Aerossol (CEREC Optispray)	PEEK Post Bond Strength	- Improvement of bond strength in groups with surface treatment - Higher bond strength in the coronal part than apical, regardless of the surface treatment.	PEEK posts with surface treatments (sulphuric acid, abrasion by airborne particles, non-thermal plasma) increase resistance with resin cement.

Jafarian et al. 2020	*In Vitro*	Human premolars	IOS (TRIOS - 3Shape) + Milled post Hybrid Technique (Acrylic resin + IOS Scanner (TRIOS 3) Cast Post)	Scan posts (PS1.4 – 3Shape)	Adaptation (volume, apical gap, coronal adaptation and retention)	- The Hybrid Technique with cast posts showed greater volume precision, with better fit in round and oval canals. IOS with Scan posts increased the apical gap for oval canals. - No difference was observed in retention between the two evaluated groups, as the coronal part was well digitized.	Scan posts should be applied with caution, especially in oval canals due to the large apical space.
Leven et al. 2022	*In Vitro*	Premolars Lower Human	IOS (TRIOS 4 - 3Shape) Without Scan posts IOS (TRIOS 4 - 3Shape) With Scan posts CEREC Primescan	Scan posts (Dental Team)	Accuracy in Different IOSs Adaptation of Posts (Zirconia and Resin)	- Lower accuracy in the apical area. - Primescan showed lower accuracy compared to TRIOS 4 (with and without scan posts), but with significant differences only in some regions (external occlusal). - Greater linear discrepancies were observed with scanning using Scan posts.	Precision of fit within an acceptable clinical margin, regardless of the type of technique. The use of Scan posts is not necessary for IOS-based canal scanning.
Dupagne et al. 2023	*In Vitro*	Modelo impresso/ PM	IOS (CEREC Primescan; Omnicam; Medit i700; TRIOS 4) EOS (E3 tabletop - 3 Shape)	No	Assess measurement error (with and without adjacent teeth)	- Significant differences were observed among the IOSs. - The E3 and Omnicam scanners were, in some cases, unable to scan the conical preparation. - Primescan, TRIOS 4, and Medit i700 showed minimally significant differences. - Adjacent teeth negatively affect scanning due to obstruction of the IOS head.	Optical impressions with modern IOS appear to be an adapted method for recording root canal preparation and manufacturing of posts/cores. The adjacent tooth can negatively affect the quality of the digitally scanned root canal.
Elter et al. 2023	*In Vitro*	Inferior Canine Human	IOS (CEREC Primescan) Hybrid Technique Light Silicone + Laboratory Scanner (CEREC inEos X5)	No	Assessing the trueness of different priming depths (20, 18, 16, 14, 12, 10 mm)	- Root mean square (RMS) was significantly higher as the distance from the preparations increased (with no difference at 14/16 mm; 18/20 mm). - Preparations larger than 14 mm did not have proper readings. - Preparations larger than 14 mm did not have proper readings.	IOS appears to be a promising technology for scanning root canals, but it cannot be recommended as a routine procedure at the current stage, as the results are highly dependent on the clinical situation.

Emam et al. 2023	*In Vitro*	Upper Incisors Lower Premolars Human	IOS (CEREC Primescan; Medit i500; CS 3600) Hybrid Indirect Technique (Light Silicone)	No	Compare the trueness of IOSs at different depths (8 and 10 mm)	- Significant differences in RMS values were observed among the different scanners. - Medit i500 exhibited greater digital impression accuracy, while CS 3600 demonstrated a lower ability to capture different depths.	Different types of scanners and preparation depth can affect the scanning of the root canal.
Perlea et al. 2023	Technique Report	Molar	IOS (TRIOS 3)	Root Canal Preparation Drill	Describing a New Scanning Method	Fabrication of Hybrid Posts (Prefabricated Fiber Post + Chairside Milled Zirconia Core and Scanned by IOS) in a Single Appointment	An easy and direct method for fabricating internal hybrid pins and cores, allowing for greater patient comfort and same-day restoration
Vogler et al. 2023 [A]	*In Vitro*	Single-Rooted Teeth Humans	IOS (CEREC Primescan) – Milled Fiberglass Core Hybrid Indirect Technique (Polyether + Model + IOS of the Model) – Cast Metal Core	No	Comparison of Fit,Decementation, and Fracture after Mechanical Cycling	- Apical misfit deviation was significantly greater compared to the middle and coronal thirds. - Fiberglass cores showed less decementation and fractures compared to cast metal cores	The fully digital in-office workflow with CAD/CAM fiberglass posts can be used to manufacture custom cores for anterior teeth with extensive coronal destruction.
Campanella, et al 2019	Case Report	Inferior Canine	IOS (TRIOS) Hybrid Indirect Technique (Light Silicone + EOS (D200 – 3Shape)	No	Comparison of Fit (Using Light Silicone)	Three different clinicians evaluated the adaptation of the two cast cores (using both techniques) and chose the core obtained by the IOS. Note: Less than half of the canal was prepared.	There is still a need for conventional impression materials to achieve satisfactory adaptation and subsequent digitization. The choice of molding material depends on the clinician's skill.
Libonati, et al 2020	Case Report	PM inferior	IOS (TRIOS)	No	Customized Fiberglass Rehabilitation	- The digital technique allowed for the conversion of the concave surface of the root canal into the convex surface of the post. - Scanning of a root canal prepared to a depth of 9 mm Note: Less than half of the canal was prepared.	The use of an intraoral digital scanner represents an opportunity for the clinician, as it streamlines the production of an anatomical post and central restorations.
Vogler, et al 2023 [B]	Clinical Trial	25 patients 30 teeth (16 anterior 14 posterior))	IOS (CEREC Primescan) – Milled Fiberglass Core Hybrid Indirect Technique (Polyether + Model + IOS of the Model) Cast Metal Core	No	Fit of the fiberglass and metal cores obtained with the different techniques	The fiberglass cores obtained by IOS showed significantly better performance compared to the metal core in terms of fit accuracy ($p = 0.022$) and impression-taking feasibility ($p < 0.001$). The apical differences were greater between the evaluated techniques.	Using IOS, teeth can be restored with a single-visit digital workflow (milled fiberglass core). Within the limitations of this study, the fully digital in-office workflow resulted in superior fit accuracy and improved impression-taking feasibility compared to the conventional workflow with metal core.

Most of the studies were of an in vitro design, while only 2 studies involved a case report, and one study was a clinical experimental design, comparing patients who received digitally scanned IOS-based glass fiber post and core to patients who were rehabilitated with cast metal posts and core obtained by the hybrid indirect technique. Most of the included studies considered extracted human anterior or premolar teeth, except for one study (Perlea et al., 2023) that evaluated molars.

Different IOSs were considered by the selected studies, including CS 3600, Cerec Omnican, Primescan, Medit i500 and i700, and Trios. There is a notable prevalence of the use of Trios scanners (3 or 4) from the 3Shape company (10 of the included studies), followed by CEREC Primescan (7 of the included studies). Some studies compared more than one type of scanner (Emam et al., 2023; Dupagne et al. 2023), and both studies reported that the type of scanner can influence the scanning of the involved preparation.

Regarding the type of device used, some studies have used scan posts. The scan post is a device first developed by the company 3Shape with the aim of facilitating the precise capture of deeper positions of intraradicular preparations through a double-scan workflow. These are customized devices with different formats (compatible with: apol, pivomatic and cylindrical) with different lengths (12 to 16 mm) and diameters (0.9 to 1.75 mm). The studies chose the scan post that best fit inside the canal to facilitate scanning with the IOS. However, one study from 2022 (Leven et al., 2022) reported the use of scan posts from the company Dental Team (Sulzbach-Rosenberg, Germany), which is related to one of the study's authors. The authors did not provide information about the variations present in this artifact.

Only one study used an aerosol spray from the CEREC company (Optispray) for scanning (Atia et al., 2020). Another study used a post-space preparation drill inserted into the canal as a scanning device (Perlea et al., 2023). The idea of this study was to describe a quick and easy technique for making posts and cores, with possible chairside milling, thus allowing the patient to leave with rehabilitation on the same day.

The main characteristics assessed were fit accuracy, trueness, which includes depth reading capability, and retention ability. Some studies reported discrepancies between scanning with IOSs and control (traditional or hybrid) methods (Pinto et al., 2017; Hendy et al., 2018; Kanduti et al., 2019; Vloger et al., 2023 [A][B]; Campanella et al., 2019).

In terms of the direct comparison between the digital and hybrid techniques, Hendy et al., 2018 compared the three possibilities and indicated that the conventional technique still has higher retention values and smaller apical gaps compared to the digital techniques. However, the hybrid technique showed worse results compared to the fully digital technique. Similarly, Moustapha et al., 2019 found that the hybrid technique introduces more variables and, as a result, may have less internal adaptation with more space for cementation compared to the fully digital technique. Conversely, one study reported greater volume accuracy and a better fit for the hybrid technique compared to the fully digital IOS workflow (Jafarian et al., 2020).

Campanella et al., 2019 reported the first clinical case with the digitalization of the root canal using an IOS. The authors fabricated two cast metal cores, one obtained through digital scanning and the other obtained by scanning the silicone mold of the canal with a laboratory scanner. After the core casting, all three clinicians preferred the fit of the core obtained through IOS scanning. Similarly, Libonati et al., 2020, developed a fully digital workflow for scanning the root canal at a depth of 9 mm, subsequently producing a custom-made fiberglass post (one of the first reported). They indicated that the use of an IOS represents an opportunity for the clinician as it streamlines the production of anatomical post and anterior aesthetic restorations.

One of the factors that significantly contribute to increased discrepancies or reading difficulties with the IOS is the depth of the preparation (Pinto et al., 2017; Elter et al., 2023; Emam et al., 2023). Pinto et al., 2017, in their study on premolars with intraradicular preparations of 8.5 and 9.5 mm, found depth reading discrepancies between the indirect and digital techniques. In all cases, the shallower depth reading was for the digital technique, ranging from 10% to 40% discrepancy, which was attributed to the small sample size. For the digital technique, the smallest discrepancies were observed when the entrances of the root canals were larger. In this same line, Elter et al., 2023, found that root preparations larger than 14 mm (14, 16, 18, and 20 mm) did not achieve adequate readings. Emam et al., 2023, also emphasized that besides depth, certain types of scanners may contribute to deeper readings compared to others, and this should also be taken into account. None of these studies considered the use of some devices, such as scan posts.

Kanduti et al., 2019, evaluated the TRIOS 3 Shape scanner compared to micro-CT and reported that it can accurately measure up to 4 mm of the root canal. Precision was similar for both techniques in the cervical region, an area of importance for retention and fracture resistance. These same findings were found in the studies by Hendy et al., 2018, and Jafarian et al., 2020. According to Hendy et al., 2018, digital and semi-digital techniques should not be recommended as an alternative to the conventional technique. For retention capacity, the digital technique was better than the semi-digital, and the conventional technique showed better apical adaptation and retention than the others. However, the measured apical gap was up to 1 mm, within the 2 mm parameter considered acceptable for clinical success (Moshonov et al., 2005). Jafarian et al., 2020, found apical gaps larger than 2 mm for oval canals and did not recommend the use of scan posts for them. However, the same scanning post provided better results for round canals. Regarding retention, which was also evaluated in this study, the techniques did not show significant differences. This could be explained by good coronal adaptation achieved through effective scanner capture, regardless of the canal shape.

The study by Atia et al., 2020, evaluated the push-out resistance of hybrid posts with various surface treatments, manufactured from digital scans using the Cerec Primescan IOS. The posts with surface treatment improved bond strength, with better results in the coronal part, regardless of the type of surface treatment. The study by Elter et al., 2023, evaluated the accuracy of this IOS by comparing it to scanning with a laboratory scanner of a polyvinyl siloxane impression. They found that the best accuracy was achieved at depths of up to 14 mm and in diameters larger than 2.2 mm.

Emam et al. also compared the accuracy of Primescan, and it showed lower accuracy compared to Medit i500, with much shallower depths in their study. The other scanner they evaluated, the CS 3600, did not achieve good accuracy at depths of 8 and 10 mm. Vogler et al., 2023 reported satisfactory results with Primescan in both of their studies. In the fabrication of milled fiberglass posts, these posts exhibited superior mechanical behavior and better-fit accuracy compared to metal posts. This allows for esthetic rehabilitation of anterior teeth with extensive coronal destruction. When evaluated in a clinical trial, this fit accuracy remained superior to metal posts and showed better impression-taking feasibility, enabling the completion of the work in a single session.

Leven et al., 2023 evaluated the accuracy and fit of zirconia and resin posts using two IOSs. Primescan exhibited lower accuracy than TRIOS 4 Shape, both with and without the use of scan posts. However, the fit accuracy remained within an acceptable range. Nonetheless, the use of scan posts was not recommended, as it resulted in larger linear discrepancies when used.

Dupagne et al., 2023 assessed the measurement error and the influence of the presence or absence of adjacent teeth using four different IOS models. Significant differences were observed between the scanners. In some cases, a laboratory scanner and Omnicam were unable to scan conical preparations. Primescan, TRIOS 4, and Medit i700 showed minimal differences, but all of them were negatively affected by the presence of adjacent teeth due to obstruction of the IOS head.

4. DISCUSSION

According to our knowledge, this is the first review aiming to provide a synthesis of the use of IOS for the fabrication of intraradicular posts. Few studies are available, and the evaluation methods vary significantly. However, it's important to highlight the ongoing efforts to improve IOS devices and techniques for the fabrication of more precise intraradicular posts, which are increasingly being researched. The intraoral scanning techniques and scanners currently available should be familiar to professionals who need to rehabilitate teeth with extensive coronal destruction using retainers.

With the emergence of new models of IOSs in 2019, promising sharpness and reading accuracy at depths of up to 20 mm (Cerec Primescan), more studies have begun to evaluate the precision and accuracy of these IOSs in scanning root canals. Accuracy and precision, although assessed separately, together determine the accuracy of IOSs (Eman et al., 2023). Accuracy is the ability of a measurement to correspond to the true value and is directly influenced by the object to be scanned, the type of scanning, the distance to the object (Ashraf et al., 2020), the scanner tip, lighting conditions, ambient temperature, scanning duration (Arakida et al., 2018), and operator experience (Lim et al., 2018). Precision is the ability of a measurement to be consistently reproduced.

The scanning range of IOSs is affected by the level of illumination (Ma et al., 2023). Revilla-leon et al., (2020) reported in their study that both lighting conditions and ambient temperature (Arakida et al., 2019) directly interfere with the scanning capabilities of IOSs. This explains why Pinto et al., 2017 mentioned difficulties in reading deep and narrow canals in lower light conditions. For Elter et al. 2023, an increase in depth affected the accuracy of scans, with readings no longer being suitable above 14 mm. In the study by Eman et al., 2023, the scanning depth reached up to 10 mm, emphasizing the need for an experienced operator to ensure that the IOS tip can access the entire area to be scanned. In the two case reports included in this work (Campanella et al., 2019; Libonatti et al., 2020), both authors encountered situations where the reading and use of the post fell short of half the length of the root remnant. This is important because a minimum length of the retainer inside the conduit is necessary to avoid leverage between the fulcrum of the material and the associated supporting tissue.

Another important factor, which was only considered in one study, is the presence of adjacent teeth. According to Dupagne et al. 2023, the presence of adjacent teeth makes it difficult to scan conduits, as it limits the introduction of the scanner head over the tooth, making it difficult for the light to reach the depth of the conduit.

The manufacture of an anatomical post is important to guarantee the retention and resistance properties and reduce the risk of system failure. This finding can be corroborated by Da Costa et al., 2017, who reported that CAD-CAM customization was able to significantly reduce the thickness of the cement layer, with 90% of the sample showing no gaps between the dentin wall and the post. For Al-Qarni., 2022 customized CAD-CAM posts can be considered as an alternative technique to the traditional ones, presenting good marginal adaptation and resistance to fracture, as well as superior aesthetics. Perlea et al., 2023 used the preparation drill itself inside the canal during scanning, which was carried out with and without the drill, reducing the need for scanning posts to make intraradicular retainers. Zirconia and ceramic cores were then fabricated where prefabricated fiberglass posts fit, creating a more perfect fit at the coronal level, all of this in just a few working hours, allowing the patient to receive the restoration on the same day. Accelerating the fabrication of posts and crowns through a fully digital workflow improves the patient experience in the dental office (Siqueira et al., 2021), increasing comfort and reducing anxiety since it doesn't require conventional impressions, reduces visits to the dentist (Lee, 2014) and produces a virtual image that allows a better perception of the finished work (Ciciu et al., 2020).

The use of scanning poles improves the depth reading of root canals but does not provide posts that are better adjusted to these canals (Pinto et al., 2017). This is linked to the fact that root canals can have very different anatomies. The study by Leven et al., 2022, the only one that considered a comparison with and without scan posts, disagrees with the need for scan posts or similar for the scan to provide retainers that are better adjusted to the root canal. Retainers that were manufactured from scanning with scan posts also showed lower precision in the study by Jafarian et al., 2020, and it recommends that these should be used cautiously, especially in oval canals. Not all scan posts are standardized for IOSs, and some manufacturers do not provide guidelines for their use, which may have influenced the study's results. Additionally, each tooth may have a specific and particular characteristic regarding the root canal, so the use of a standardized prefabricated device can interfere with the internal adaptation process, especially due to the lack of individualization within the canal. Therefore, hardware and software improvements are necessary to ensure that light can reach these deeper spaces and allow for a good digital impression, regardless of root canal anatomy.

It is a consensus in all these studies that the digital system for making intraradicular posts still has a lot to improve. Despite the numerous advantages such as reducing appointments, patient comfort, and precision, IOSs have the disadvantage of high cost, making it difficult to become routine for most professionals. Another important point is the slow learning curve for operation, which requires dedication and effort. The new IOSs currently available in the market promise deeper and more accurate readings of spaces for pins. However, there have been no consistent studies published considering the new models of IOSs for scanning the root canal. It's important that new in vivo studies consider the clinical variables that can interfere with IOS scanning, such as saliva, mouth opening, the quadrant to be scanned, operator skill, and the operator's learning curve, among others, to provide better guidelines for scanning canals and creating more accurate intraradicular posts.

5. CONCLUSIONS

The fully digital workflow with IOS appears to be a promising alternative for the rehabilitation of endodontically treated teeth. However, the use of IOS for scanning of the root canal preparation requires improvements because some factors such as canal depth, the presence of a scan post, and the type of scanner used can influence and directly affect the accuracy values of the scan, and consequently, the fit of the future post inside the root canal. Therefore, future standardized clinical studies are recommended for better evidence of the highlighted factors.

6. REFERENCES

- Akbari, M.A.H., Jamali, H., Gholami, A.A., Majidinia, S. (2016) One-Year Clinical Comparison of Survival of Endodontically Treated Premolar Restored with Different Direct Restoration Technique: A Prospective Cohort Study*. Razavi Int. J. Med. Inpress* 2016,4,e39800 http://dx.doi.org/10.17795/rijm39800
- Al-Qarni F. D. (2022). Customized Post and Cores Fabricated with CAD/CAM Technology: A Literature Review. *International journal of general medicine*, *15*, 4771–4779. https://doi.org/10.2147/IJGM.S365296
- Alzahrani, S. J., El-Hammali, H., Morgano, S. M., & Elkassaby, H. (2021). Evaluation of the accuracy of 2 digital intraoral scanners: A 3D analysis study. *The Journal of prosthetic dentistry*, *126*(6), 787–792. https://doi.org/10.1016/j.prosdent.2020.10.004
- Arakida, T., Kanazawa, M., Iwaki, M., Suzuki, T., & Minakuchi, S. (2018). Evaluating the influence of ambient light on scanning trueness, precision, and time of intra oral scanner. *Journal of prosthodontic research*, *62*(3), 324–329. https://doi.org/10.1016/j.jpor.2017.12.005
- Ashraf, Y., Sabet, A., Hamdy, A., & Ebeid, K. (2020). Influence of Preparation Type and Tooth Geometry on the Accuracy of Different Intraoral Scanners. *Journal of prosthodontics : official journal of the American College of Prosthodontists*, *29*(9), 800–804. https://doi.org/10.1111/jopr.13202
- Attia, M. A., Shokry, T. E., & Abdel-Aziz, M. (2022). Effect of different surface treatments on the bond strength of milled polyetheretherketone posts. *The Journal of prosthetic dentistry*, *127*(6), 866–874. https://doi.org/10.1016/j.prosdent.2020.08.033
- Awad, M. A., & Marghalani, T. Y. (2007). Fabrication of a custom-made ceramic post and core using CAD-CAM technology. *The Journal of prosthetic dentistry*, *98*(2), 161–162. https://doi.org/10.1016/S0022-3913(07)60050-X
- Bittner, N., Hill, T., & Randi, A. (2010). Evaluation of a one-piece milled zirconia post and core with different post-and-core systems: An in vitro study. *The Journal of prosthetic dentistry*, *103*(6), 369–379. https://doi.org/10.1016/S0022-3913(10)60080-7
- Campanella, V., Carosi, P., Casella, S., Pinto, A., & Di Girolamo, M. (2019). Clinical fitting of a cast metal post and core obtained by means of an intraoral optical scanning (IOS) and digital workflow. *Journal of biological regulators and homeostatic agents*, *33*(3 Suppl. 1)

- Cicciù, M., Fiorillo, L., D'Amico, C., Gambino, D., Amantia, E. M., Laino, L., Crimi, S., Campagna, P., Bianchi, A., Herford, A. S., & Cervino, G. (2020). 3D Digital Impression Systems Compared with Traditional Techniques in Dentistry: A Recent Data Systematic Review. *Materials (Basel, Switzerland)*, *13*(8), 1982. https://doi.org/10.3390/ma13081982
- da Costa RG, Freire A, Caregnatto de Morais EC, Machado de Souza E, Correr GM, Rached RN.(2017) Effect of CAD/CAM glass fiber post-core on cement micromorphology and fracture resistance of endodontically treated roots. *Am J Dent*; 30:3–8.
- Dupagne L, Mawussi B, Tapie L, Lebon N. Comparison of the measurement error of optical impressions obtained with four intraoral and one extra-oral dental scanners of post and core preparations. Heliyon. 2023 Jan 25;9(2):e13235. doi: 10.1016/j.heliyon.2023.e13235. PMID: 36747555; PMCID: PMC9898050.
- Elter, B., Diker, B., & Tak, Ö. (2022). The trueness of an intraoral scanner in scanning different post space depths. *Journal of dentistry*, *127*, 104352. https://doi.org/10.1016/j.jdent.2022.104352
- Emam, M., Ghanem, L., & Abdel Sadek, H. M. (2023). Effect of different intraoral scanners and post-space depths on the trueness of digital impressions. *Dental and medical problems*, 10.17219/dmp/162573. Advance online publication. https://doi.org/10.17219/dmp/162573
- Grandini, S., Goracci, C., Tay, F. R., Grandini, R., & Ferrari, M. (2005). Clinical evaluation of the use of fiber posts and direct resin restorations for endodontically treated teeth. *The International journal of prosthodontics*, *18*(5), 399–404.
- Gurpinar, B., & Tak, O. (2022). Effect of pulp chamber depth on the accuracy of endocrown scans made with different intraoral scanners versus an industrial scanner: An in vitro study. *The Journal of prosthetic dentistry*, *127*(3), 430–437. https://doi.org/10.1016/j.prosdent.2020.08.034
- Hendi, A. R., Moharrami, M., Siadat, H., Hajmiragha, H., & Alikhasi, M. (2019). The effect of conventional, half-digital, and full-digital fabrication techniques on the retention and apical gap of post and core restorations. *The Journal of prosthetic dentistry*, *121*(2), 364.e1–364.e6. https://doi.org/10.1016/j.prosdent.2018.09.014
- Kanduti, D., Korat, L., Kosec, T., Legat, A., Ovsenik, M., & Kopač, I. (2021). Comparison Between Accuracy of Posts Fabricated Using a Digital CAD/CAM

Technique and a Conventional Direct Technique. *The International journal of prosthodontics*, *34*(2), 212–220. https://doi.org/10.11607/ijp.6502

- Kihara, H., Hatakeyama, W., Komine, F., Takafuji, K., Takahashi, T., Yokota, J., Oriso, K., & Kondo, H. (2020). Accuracy and practicality of intraoral scanner in dentistry: A literature review. *Journal of prosthodontic research*, *64*(2), 109–113. https://doi.org/10.1016/j.jpor.2019.07.010
- Lee J. H. (2014). Accelerated techniques for a post and core and a crown restoration with intraoral digital scanners and CAD/CAM and rapid prototyping. *The Journal of prosthetic dentistry*, *112*(5), 1024–1029. https://doi.org/10.1016/j.prosdent.2014.04.019
- Leven, R., Schmidt, A., Binder, R., Kampschulte, M., Vogler, J., Wöstmann, B., & Schlenz, M. A. (2022). Accuracy of Digital Impression Taking with Intraoral Scanners and Fabrication of CAD/CAM Posts and Cores in a Fully Digital Workflow. *Materials (Basel, Switzerland)*, *15*(12), 4199. https://doi.org/10.3390/ma15124199
- Libonati, A., Di Taranto, V., Gallusi, G., Montemurro, E., & Campanella, V. (2020). CAD/CAM Customized Glass Fiber Post and Core With Digital Intraoral Impression: A Case Report. *Clinical, cosmetic and investigational dentistry*, *12*, 17–24. https://doi.org/10.2147/CCIDE.S237442
- Lim, J. H., Park, J. M., Kim, M., Heo, S. J., & Myung, J. Y. (2018). Comparison of digital intraoral scanner reproducibility and image trueness considering repetitive experience. *The Journal of prosthetic dentistry*, *119*(2), 225–232. https://doi.org/10.1016/j.prosdent.2017.05.002
- Liu, W., Qing, H., Pei, X., & Wang, J. (2019). Internal adaptation of cobalt-chromium posts fabricated by selective laser melting technology. *The Journal of prosthetic dentistry*, *121*(3), 455–460. https://doi.org/10.1016/j.prosdent.2018.03.017
- Ma, Y., Guo, Y. Q., Saleh, M. Q., & Yu, H. (2023). Influence of ambient light conditions on intraoral scanning: A systematic review. *Journal of prosthodontic research*, 10.2186/jpr.JPR_D_23_00098. Advance online publication. https://doi.org/10.2186/jpr.JPR_D_23_00098
- Martins, M. D., Junqueira, R. B., de Carvalho, R. F., Lacerda, M. F. L. S., Faé, D. S., & Lemos, C. A. A. (2021). Is a fiber post better than a metal post for the restoration of endodontically treated teeth? A systematic review and meta-analysis. *Journal of dentistry*, *112*, 103750. https://doi.org/10.1016/j.jdent.2021.103750

- Morgano, S. M., Rodrigues, A. H., & Sabrosa, C. E. (2004). Restoration of endodontically treated teeth. *Dental clinics of North America*, *48*(2), vi–416. https://doi.org/10.1016/j.cden.2003.12.011
- Moshonov, J., Slutzky-Goldberg, I., Gottlieb, A., & Peretz, B. (2005). The effect of the distance between post and residual gutta-percha on the clinical outcome of endodontic treatment. *Journal of endodontics*, *31*(3), 177–179. https://doi.org/10.1097/01.don.0000137646.07662.8e
- Moustapha, G., AlShwaimi, E., Silwadi, M., Ounsi, H., Ferrari, M., & Salameh, Z. (2019). Marginal and internal fit of CAD/CAM fiber post and cores. *International journal of computerized dentistry*, *22*(1), 45–53.
- Perlea, P., Stefanescu, C., Al-Aloul, O. A., Ionita, C., & Petre, A. E. (2023). Digital Workflow for Producing Hybrid Posts and Cores. *Healthcare (Basel, Switzerland)*, *11*(5), 727. https://doi.org/10.3390/healthcare11050727
- Perucelli, F., Goulart da Costa, R., Machado de Souza, E., & Rached, R. N. (2021). Effect of half-digital workflows on the adaptation of custom CAD-CAM composite post-and-cores. *The Journal of prosthetic dentistry*, *126*(6), 756–762. https://doi.org/10.1016/j.prosdent.2020.08.014
- Peters, M. D., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *International journal of evidence-based healthcare*, *13*(3), 141–146. https://doi.org/10.1097/XEB.0000000000000050
- Pinto, A., Arcuri, L., Carosi, P., Nardi, R., Libonati, A., Ottria, L., & Campanella, V. (2017). *In vitro* evaluation of the post-space depth reading with an intraoral scanner (IOS) compared to a traditional silicon impression. *ORAL & implantology*, *10*(4), 360–368. https://doi.org/10.11138/orl/2017.10.4.360
- Revilla-León, M., Subramanian, S. G., Att, W., & Krishnamurthy, V. R. (2021). Analysis of Different Illuminance of the Room Lighting Condition on the Accuracy (Trueness and Precision) of An Intraoral Scanner. *Journal of prosthodontics : official journal of the American College of Prosthodontists*, *30*(2), 157–162. https://doi.org/10.1111/jopr.13276
- Salvi, G. E., Siegrist Guldener, B. E., Amstad, T., Joss, A., & Lang, N. P. (2007). Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting. *International endodontic journal*, *40*(3), 209–215.

https://doi.org/10.1111/j.1365-2591.2007.01218.x

- Siqueira, R., Galli, M., Chen, Z., Mendonça, G., Meirelles, L., Wang, H. L., & Chan, H. L. (2021). Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review. *Clinical oral investigations*, *25*(12), 6517–6531. https://doi.org/10.1007/s00784-021-04157-3
- Tang, W., Wu, Y., & Smales, R. J. (2010). Identifying and reducing risks for potential fractures in endodontically treated teeth. *Journal of endodontics*, *36*(4), 609–617. https://doi.org/10.1016/j.joen.2009.12.002
- Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., Lewin, S., … Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of internal medicine*, *169*(7), 467–473. https://doi.org/10.7326/M18-0850
- Tsintsadze, N., Juloski, J., Carrabba, M., Goracci, C., Vichi, A., Grandini, S., & Ferrari, M. (2018). Effects of scanning technique on in vitro performance of CAD/CAM-fabricated fiber posts. *Journal of oral science*, *60*(2), 262–268. https://doi.org/10.2334/josnusd.17-0254
- Vinothkumar, T. S., Kandaswamy, D., & Chanana, P. (2011). CAD/CAM fabricated single-unit all-ceramic post-core-crown restoration. *Journal of conservative dentistry : JCD*, *14*(1), 86–89. https://doi.org/10.4103/0972-0707.80730
- Vogler, J. A. H., Billen, L., Walther, K. A., & Wöstmann, B. (2023). Conventional cast vs. CAD/CAM post and core in a fully digital chairside workflow - An in vivo comparative study of accuracy of fit and feasibility of impression taking. *Journal of dentistry*, *136*, 104638. https://doi.org/10.1016/j.jdent.2023.104638
- Vogler, J. A. H., Billen, L., Walther, K. A., & Wöstmann, B. (2023). Fibre-reinforced Cad/CAM post and cores: The new "gold standard" for anterior teeth with extensive coronal destruction?-A fully digital chairside workflow. *Heliyon*, *9*(8), e19048. https://doi.org/10.1016/j.heliyon.2023.e19048

3 CONCLUSÃO

Dentro das limitações desse estudo, é possível concluir que tanto o uso de retentores intrarradiculares para reconstruções de dentes tratados endodonticamente devem ser considerados uma opção favorável de tratamento, tendo em vista que reduzem o risco de falhas em determinadas situações clínicas. Além disso, foi verificado que a utilização da tecnologia CAD/CAM tem sido considerada uma alternativa inovadora e importante para o tratamento reabilitador desses casos, e a utilização do escâner intraoral para a fabricação de um conjunto (pino e núcleo) para reconstrução de dentes tratatados endonticamente apesar de viável, ainda carece de informações científicas e ensaios clínicos de longo prazo.

4 REFERÊNCIAS

- Al-Qarni F. D. (2022). Customized Post and Cores Fabricated with CAD/CAM Technology: A Literature Review. *International journal of general medicine*, *15*, 4771–4779. https://doi.org/10.1155/2022/8621835
- Al-Omiri, M. K., Mahmoud, A. A., Rayyan, M. R., & Abu-Hammad, O. (2010). Fracture resistance of teeth restored with post-retained restorations: an overview. *Journal of endodontics*, *36*(9), 1439–1449. https://doi.org/10.1016/j.joen.2010.06.005
- Alzahrani, S. J., El-Hammali, H., Morgano, S. M., & Elkassaby, H. (2021). Evaluation of the accuracy of 2 digital intraoral scanners: A 3D analysis study. *The Journal of prosthetic dentistry*, *126*(6), 787–792. https://doi.org/10.1016/j.prosdent.2020.10.004
- Attia, M. A., Shokry, T. E., & Abdel-Aziz, M. (2022). Effect of different surface treatments on the bond strength of milled polyetheretherketone posts. *The Journal of prosthetic dentistry*, *127*(6), 866–874. https://doi.org/10.1016/j.prosdent.2020.08.033
- Awad, M. A., & Marghalani, T. Y. (2007). Fabrication of a custom-made ceramic post and core using CAD-CAM technology. *The Journal of prosthetic dentistry*, *98*(2), 161–162. https://doi.org/10.1016/S0022-3913(07)60050-X
- Balkenhol, M., Wöstmann, B., Rein, C., & Ferger, P. (2007). Survival time of cast post and cores: a 10-year retrospective study. *Journal of dentistry*, *35*(1), 50–58. https://doi.org/10.1155/2022/8621835
- Bittner, N., Hill, T., & Randi, A. (2010). Evaluation of a one-piece milled zirconia post and core with different post-and-core systems: An in vitro study. *The Journal of prosthetic dentistry*, *103*(6), 369–379. https://doi.org/10.1155/2022/8621835
- Cagidiaco, M. C., García-Godoy, F., Vichi, A., Grandini, S., Goracci, C., & Ferrari, M. (2008). Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars. *American journal of dentistry*, *21*(3), 179–184.
- Cicciù, M., Fiorillo, L., D'Amico, C., Gambino, D., Amantia, E. M., Laino, L., Crimi, S., Campagna, P., Bianchi, A., Herford, A. S., & Cervino, G. (2020). 3D Digital Impression Systems Compared with Traditional Techniques in Dentistry: A Recent Data Systematic Review. *Materials (Basel, Switzerland)*, *13*(8), 1982. https://doi.org/10.1155/2022/8621835

- Cloet, E., Debels, E., & Naert, I. (2017). Controlled Clinical Trial on the Outcome of Glass Fiber Composite Cores Versus Wrought Posts and Cast Cores for the Restoration of Endodontically Treated Teeth: A 5-Year Follow-up Study. *The International journal of prosthodontics*, *30*(1), 71–79. https://doi.org/10.1155/2022/8621835
- Da Costa RG, Freire A, Caregnatto de Morais EC, Machado de Souza E, Correr GM, Rached RN.(2017) Effect of CAD/CAM glass fiber post-core on cement micromorphology and fracture resistance of endodontically treated roots. *Am J Dent*; 30:3–8.
- Elter, B., Diker, B., & Tak, Ö. (2022). The trueness of an intraoral scanner in scanning different post space depths. *Journal of dentistry*, *127*, 104352. https://doi.org/10.1016/j.jdent.2022.104352
- Ferrari, M., Cagidiaco, M. C., Grandini, S., De Sanctis, M., & Goracci, C. (2007). Post placement affects survival of endodontically treated premolars. *Journal of dental research*, *86*(8), 729–734. https://doi.org/10.1177/154405910708600808
- Ferrari, M., Ferrari Cagidiaco, E., Goracci, C., Sorrentino, R., Zarone, F., Grandini, S., & Joda, T. (2019). Posterior partial crowns out of lithium disilicate (LS2) with or without posts: A randomized controlled prospective clinical trial with a 3-year follow up. *Journal of dentistry*, *83*, 12–17. https://doi.org/10.1016/j.jdent.2019.01.004
- Ferrari, M., Vichi, A., & García-Godoy, F. (2000). Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. *American journal of dentistry*, *13*(Spec No), 15B–18B.
- Grandini, S., Goracci, C., Tay, F. R., Grandini, R., & Ferrari, M. (2005). Clinical evaluation of the use of fiber posts and direct resin restorations for endodontically treated teeth. *The International journal of prosthodontics*, *18*(5), 399–404.
- Goracci, C., & Ferrari, M. (2011). Current perspectives on post systems: a literature review. *Australian dental journal*, *56 Suppl 1*, 77–83. https://doi.org/10.1155/2022/8621835
- Gutiérrez, M. A., Guerrero, C. A., & Baldion, P. A. (2022). Efficacy of CAD/CAM Glass Fiber Posts for the Restoration of Endodontically Treated Teeth. *International journal of biomaterials*, *2022*, 8621835. https://doi.org/10.1155/2022/8621835
- Hendi, A. R., Moharrami, M., Siadat, H., Hajmiragha, H., & Alikhasi, M. (2019). The effect of conventional, half-digital, and full-digital fabrication techniques on the

retention and apical gap of post and core restorations. *The Journal of prosthetic dentistry*, *121*(2), 364.e1–364.e6. https://doi.org/10.1016/j.prosdent.2018.09.014

- Junqueira, R. B., de Carvalho, R. F., Marinho, C. C., Valera, M. C., & Carvalho, C. A. T. (2017). Influence of glass fibre post length and remaining dentine thickness on the fracture resistance of root filled teeth. *International endodontic journal*, *50*(6), 569–577. https://doi.org/10.1111/iej.12653
- Jurema, A. B., Bresciani, E., & Caneppele, T. (2021). Influence of glass fiber posts on the fracture susceptibility of endodontically treated maxillary anterior teeth with direct veneers: Preliminary results of a randomized clinical trial. *Journal of esthetic and restorative dentistry : official publication of the American Academy of Esthetic Dentistry ... [et al.]*, *33*(4), 613–620. https://doi.org/10.1111/jerd.12669
- Kihara, H., Hatakeyama, W., Komine, F., Takafuji, K., Takahashi, T., Yokota, J., Oriso, K., & Kondo, H. (2020). Accuracy and practicality of intraoral scanner in dentistry: A literature review. *Journal of prosthodontic research*, *64*(2), 109–113. https://doi.org/10.1016/j.jpor.2019.07.010
- Koosha, S., Jebelizadeh, M. S., & Mostafavi, A. S. (2023). Effect of Ferrule Location on Fracture Resistance of Maxillary Premolars: An In Vitro Study. *International journal of dentistry*, *2023*, 9513804. https://doi.org/10.1155/2023/9513804
- Leven, R., Schmidt, A., Binder, R., Kampschulte, M., Vogler, J., Wöstmann, B., & Schlenz, M. A. (2022). Accuracy of Digital Impression Taking with Intraoral Scanners and Fabrication of CAD/CAM Posts and Cores in a Fully Digital Workflow. *Materials (Basel, Switzerland)*, *15*(12), 4199. https://doi.org/10.3390/ma15124199
- Martins, M. D., Junqueira, R. B., de Carvalho, R. F., Lacerda, M. F. L. S., Faé, D. S., & Lemos, C. A. A. (2021). Is a fiber post better than a metal post for the restoration of endodontically treated teeth? A systematic review and meta-analysis. *Journal of dentistry*, *112*, 103750. https://doi.org/10.1016/j.jdent.2021.103750
- Markarian, R. A., Feitosa Filho, M., & Vasconcelos, E. (2019). Model-less digital workflow for the replication of an existing complete fixed implant-supported prosthesis using an intraoral scanner. *Clinical case reports*, *7*(3), 500–505. https://doi.org/10.1002/ccr3.2012
- Ming, X., Zhang, Z., Xie, W., Zhang, Y., Li, Y., & Zhang, W. (2023). Internal adaptation and mechanical properties of CAD/CAM glass fiber post-cores in molars:

An in vitro study. *Journal of dentistry*, *138*, 104685. Advance online publication. https://doi.org/10.1016/j.jdent.2023.104685

- Morgano, S. M., Rodrigues, A. H., & Sabrosa, C. E. (2004). Restoration of endodontically treated teeth. *Dental clinics of North America*, *48*(2), vi–416. https://doi.org/10.1016/j.cden.2003.12.011
- Moshonov, J., Slutzky-Goldberg, I., Gottlieb, A., & Peretz, B. (2005). The effect of the distance between post and residual gutta-percha on the clinical outcome of endodontic treatment. *Journal of endodontics*, *31*(3), 177–179. https://doi.org/10.1097/01.don.0000137646.07662.8e
- Naumann, M., Schmitter, M., & Krastl, G. (2018). Postendodontic Restoration: Endodontic Post-and-Core or No Post At All?. *The journal of adhesive dentistry*, *20*(1), 19–24. https://doi.org/10.3290/j.jad.a39961
- Pinto, A., Arcuri, L., Carosi, P., Nardi, R., Libonati, A., Ottria, L., & Campanella, V. (2017). *In vitro* evaluation of the post-space depth reading with an intraoral scanner (IOS) compared to a traditional silicon impression. *ORAL & implantology*, *10*(4), 360–368. https://doi.org/10.11138/orl/2017.10.4.360
- Pontoriero, D., Grandini, S., Spagnuolo, G., Discepoli, N., Benedicenti, S., Maccagnola, V., Mosca, A., Ferrari Cagidiaco, E., & Ferrari, M. (2021). Clinical Outcomes of Endodontic Treatments and Restorations with and without Posts Up to 18 Years. *Journal of clinical medicine*, *10*(5), 908. https://doi.org/10.3390/
- Raedel, M., Hartmann, A., Bohm, S., & Walter, M. H. (2015). Three-year outcomes of root canal treatment: Mining an insurance database. *Journal of dentistry*, *43*(4), 412–417. https://doi.org/10.1016/j.jdent.2015.01.013
- Rocha, A. T., Gonçalves, L. M., Vasconcelos, A. J. C., Matos Maia Filho, E., Nunes Carvalho, C., & De Jesus Tavarez, R. R. (2017). Effect of Anatomical Customization of the Fiber Post on the Bond Strength of a Self-Adhesive Resin Cement. *International journal of dentistry*, *2017*, 5010712. https://doi.org/10.1155/2017/5010712

- Salameh Z, Sorrentino R, Papacchini F, Ounsi HF, Tashkandi E, Goracci C, Ferrari M. Fracture resistance and failure patterns of endodontically treated mandibular molars restored using resin composite with or without translucent glass fiber posts. J

Endod. 2006 Aug;32(8):752-5. doi: 10.1016/j.joen.2006.02.002. Epub 2006 Jun 15. PMID: 16861075.

- Salvi, G. E., Siegrist Guldener, B. E., Amstad, T., Joss, A., & Lang, N. P. (2007). Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting. *International endodontic journal*, *40*(3), 209–215. https://doi.org/10.1111/j.1365-2591.2007.01218.x
- Siqueira, R., Galli, M., Chen, Z., Mendonça, G., Meirelles, L., Wang, H. L., & Chan, H. L. (2021). Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: a systematic review. *Clinical oral investigations*, *25*(12), 6517–6531. https://doi.org/10.1007/s00784-021-04157-3
- Slutzky-Goldberg, I., Maree, M., Liberman, R., & Heling, I. (2004). Effect of sodium hypochlorite on dentin microhardness. *Journal of endodontics*, *30*(12), 880–882. https://doi.org/10.1097/01.don.0000128748.05148.1e
- Suzaki, N., Yamaguchi, S., Nambu, E., Tanaka, R., Imazato, S., & Hayashi, M. (2021). Fabricated CAD/CAM Post-Core Using Glass Fiber-Reinforced Resin Shows Innovative Potential in Restoring Pulpless Teeth. *Materials (Basel, Switzerland)*, *14*(20), 6199. https://doi.org/10.3390/ma14206199
- Tang, W., Wu, Y., & Smales, R. J. (2010). Identifying and reducing risks for potential fractures in endodontically treated teeth. *Journal of endodontics*, *36*(4), 609–617. https://doi.org/10.1016/j.joen.2009.12.002
- Tsintsadze, N., Juloski, J., Carrabba, M., Goracci, C., Vichi, A., Grandini, S., & Ferrari, M. (2018). Effects of scanning technique on in vitro performance of CAD/CAM-fabricated fiber posts. *Journal of oral science*, *60*(2), 262–268. https://doi.org/10.2334/josnusd.17-0254
- Zicari, F., Van Meerbeek, B., Debels, E., Lesaffre, E., & Naert, I. (2011). An up to 3-Year Controlled Clinical Trial Comparing the Outcome of Glass Fiber Posts and Composite Cores with Gold Alloy-Based Posts and Cores for the Restoration of Endodontically Treated Teeth. *The International journal of prosthodontics*, *24*(4), 363–372.

APÊNDICE A – Normas revista artigo 1 enviado

DENTAL MATERIALS

Official Publication of the Academy of Dental Materials

AUTHOR INFORMATION PACK

TABLE OF CONTENTS

ISSN: 0109-5641

DESCRIPTION

Online submission and editorial system now available here.

Dental Materials publishes original research and review articles.

Academy of Dental Materials members click here to register for free access to Dental Materials online.

The principal aim of *Dental Materials* is to promote rapid communication of scientific information between academia, industry, and the dental practitioner. Original Manuscripts on clinical and laboratory research of basic and applied character which focus on the **properties** or **performance** of **dental materials** or the **reaction** of host tissues to materials are given priority publication. Other acceptable topics include application technology in **clinical dentistry** and dental laboratory technology.

Comprehensive reviews and editorial commentaries on pertinent subjects will be considered.

AUDIENCE

Dental research scientists, materials scientists, clinicians, students of dentistry, dental materials and equipment manufacturers.

ABSTRACTING AND INDEXING

Science Citation Index International
Aerospace AbstractsMaterials
Science Citation Index
PubMed/Medline
METADEX
SIIC Data Bases Solid
State Abstracts
CSA Civil Engineering Abstracts
CSA Mechanical & Transportation Engineering AbstractsCeramic
Abstracts
Computer and Information Systems Abstract
Corrosion Abstracts
Current Contents
Dental Abstracts
Earthquake Engineering Abstracts
Electronics and Communications Abstracts
Aluminium Industry Abstracts
CSA Advanced Polymers Abstracts
CSA Engineered Materials Abstracts
Materials Business File
BIOSIS Previews
CSA Technology Research DatabaseCurrent
Contents
El Compendex Plus Engineering
Materials AbstractsInside
Conferences
Web of Science
TOXFILE
UnCover
ISI
Mechanical and Transport Engineer AbstractScopus
INSPEC

EDITORIAL BOARD

INTRODUCTION

Authors are requested to submit their original manuscript and figures via the online submission andeditorial system for *Dental Materials*. Using this online system, authors may submit manuscripts andtrack their progress through the system to publication. Reviewers can download manuscripts and submit their opinions to the editor. Editors can manage the whole submission/review/revise/publishprocess. Please register at: https://www.editorialmanager.com/dentma/default.aspx.

Dental Materials now only accepts online submissions.

The Artwork Quality Control Tool is now available to users of the online submission system. To help authors submit high-quality artwork early in the process, this tool checks the submitted artwork andother file types against the artwork requirements outlined in the Artwork Instructions to Authors on https://www.elsevier.com/artworkinstructions. The Artwork Quality Control Tool automatically checks all artwork files when they are first uploaded. Each figure/file is checked only once, so further alongin the process only new uploaded files will be checked.

Manuscripts

Submitted manuscripts must relate directly to both Materials Science and Dentistry.The journal is principally for publication of **Original Research Reports**, which should preferably investigate a defined hypothesis. Maximum length 6 journal pages (approximately 20 double-spacedtypescript pages) including illustrations and tables.

Systematic Reviews will however be considered.**Prior approval must be sought from the Editor before submission of Review Manuscripts**. Authors should send the Editor a structured abstractof the proposed review topic.Intending authors should communicate with the Editor beforehand, byemail, outlining the proposed scope of the review. Maximum length 10 journal pages (approximately33 double-spaced typescript pages) including figures and tables.

Three copies of the manuscript should be submitted: each accompanied by a set of illustrations.The requirements for submission are in accordance with the "Uniform Requirements for ManuscriptsSubmitted to Biomedical Journals", Annals of Internal Medicine, 1997,126, 36-47. All manuscripts must be written in American English. Authors are urged to write as concisely as possible.

The Editor and Publisher reserve the right to make minimal literary corrections for the sake of clarity.Authors for whom English is not the first language should have their manuscripts read by colleaguesfluent in English. If extensive English corrections are needed, authors may be charged for the cost of editing. For additional reference, consult issues of *Dental Materials* published after January 1999 or the Council of Biology Editors Style Manual (1995 ed.).

All manuscripts should be accompanied by a **letter of transmittal**, signed by each author, and statingthat the manuscript is not concurrently under consideration for publication in another journal, that all of the named authors were involved in the work leading to the publication of the paper, and thatall the named authors have read the paper before it is submitted for publication.

Always keep a backup copy of the electronic file for reference and safety.

Manuscripts not conforming to the journal style will be returned. In addition, manuscripts which arenot written in fluent English will be rejected automatically without refereeing.

For further guidance on electronic submission, please visit the Elsevier Support Center.

Page charges

This journal has no page charges.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal forreview. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

- E-mail address
- Full postal address

All necessary files have been uploaded:

Manuscript:

- Include keywords
- All figures (include relevant captions) should be embedded at their appropriate location within themansucript word document and not at the end of the document
- All tables (including titles, description, footnotes) should be embedded at their appropriate location within the mansucript word document
- Please also upload standalone artwork file versions with your submission
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print*Graphical Abstracts / Highlights files* (where applicable) *Supplemental files* (where applicable)

Further considerations

- Please do NOT add line numbering in your Word document as this will be added by the Editorial Manager system automatically and adding your own will mean duplication and your manuscript will be returned to you
- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- A competing interests statement is provided, even if the authors have no competing interests to declare
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Center.

BEFORE YOU BEGIN

Ethics in publishing

Please see our information on Ethics in publishing.

Studies in humans and animals

If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The manuscript should be in line with theRecommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals and aim for the inclusion of representative human populations (sex, age and ethnicity) as per those recommendations. The terms sex and gender should be used correctly.

Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should comply with the ARRIVE guidelines and should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Research Council's Guide for the Careand Use of Laboratory Animals and the authors should clearly indicate in the manuscript that such guidelines have been followed. The sex of animals must be indicated, and where appropriate, the influence (or association) of sex on the results of the study.

Informed consent and patient details

Studies on patients or volunteers require ethics committee approval and informed consent, which should be documented in the paper. Appropriate consents, permissions and releases must be obtained where an author wishes to include case details or other personal information or images of patients and any other individuals in an Elsevier publication. Written consents must be retained by the authorbut copies should not be provided to the journal. Only if specifically requested by the journal in exceptional circumstances (for example if a legal issue arises) the author must provide copies of theconsents or evidence that such consents have been obtained. For more information, please review the

Elsevier Policy on the Use of Images or Personal Information of Patients or other Individuals. Unlessyou have written permission from the patient (or, where applicable, the next of kin), the personal details of any patient included in any part of the article and in any supplementary materials (including all illustrations and videos) must be removed before submission.

All authors must disclose any financial and personal relationships with other people or organizationsthat could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests by uploading a word document at the submission stage where 'Conflict of Interest' is a mandatory upload item. If there are no interests to declare then please state this in the word document: 'Declarationsof interest: none

'More information.

Declaration of generative AI in scientific writing

The below guidance only refers to the writing process, and not to the use of AI tools to analyse anddraw insights from data as part of the research process.

Where authors use generative artificial intelligence (AI) and AI-assisted technologies in the writing process, authors should only use these technologies to improve readability and language. Applying the technology should be done with human oversight and control, and authors should carefully review and edit the result, as AI can generate authoritative-sounding output that can be incorrect, incomplete orbiased. AI and AI-assisted technologies should not be listed as an author or co-author, or be cited asan author. Authorship implies responsibilities and tasks that can only be attributed to and performedby humans, as outlined in Elsevier's AI policy for authors.

Authors should disclose in their manuscript the use of AI and AI-assisted technologies in the writingprocess by following the instructions below. A statement will appear in the published work. Please note that authors are ultimately responsible and accountable for the contents of the work.

Disclosure instructions

Authors must disclose the use of generative AI and AI-assisted technologies in the writing process byadding a statement at the end of their manuscript in the core manuscript file, before the References list. The statement should be placed in a new section entitled 'Declaration of Generative AI and AI- assisted technologies in the writing process'.

Statement: During the preparation of this work the author(s) used [NAME TOOL / SERVICE] in orderto [REASON]. After using this tool/service, the author(s) reviewed and edited the content as neededand take(s) full responsibility for the content of the publication.

This declaration does not apply to the use of basic tools for checking grammar, spelling, references etc. If there is nothing to disclose, there is no need to add a statement.

Submission declaration and verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, inEnglish or in any other language, including electronically without the written consent of the copyright- holder. To verify compliance, your article may be checked by Crossref Similarity Check and other originality or duplicate checking software.

Use of inclusive language

Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences,and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that referto personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. When coding terminology is used, we recommendto avoid offensive or exclusionary terms such as "master", "slave", "blacklist" and "whitelist". We suggest using alternatives that are more appropriate and (self-) explanatory such as "primary", "secondary", "blocklist" and "allowlist". These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Reporting sex- and gender-based analyses

Reporting guidance

For research involving or pertaining to humans, animals or eukaryotic cells, investigators should integrate sex and gender-based analyses (SGBA) into their research design according to funder/ sponsor requirements and best practices within a field. Authors should address the sex and/or genderdimensions of their research in their article. In cases where they cannot, they should discuss thisas a limitation to their research's generalizability. Importantly, authors should explicitly state what definitions of sex and/or gender they are applying to enhance the precision, rigor and reproducibility of their research and to avoid ambiguity or conflation of terms and the constructs to which they refer (see Definitions section below). Authors can refer to the Sex and Gender Equity in Research (SAGER) guidelines and the SAGER guidelines checklist. These offer systematic approaches to the useand editorial review of sex and gender information in study design, data analysis, outcome reporting and research interpretation - however, please note there is no single, universally agreed-upon set ofguidelines for defining sex and gender.

Definitions

Sex generally refers to a set of biological attributes that are associated with physical and physiological features (e.g., chromosomal genotype, hormonal levels, internal and external anatomy). A binary sexcategorization (male/female) is usually designated at birth ("sex assigned at birth"), most often based solely on the visible external anatomy of a newborn. Gender generally refers to socially constructedroles, behaviors, and identities of women, men and gender-diverse people that occur in a historical and cultural context and may vary across societies and over time. Gender influences how people viewthemselves and each other, how they behave and interact and how power is distributed in society. Sexand gender are often incorrectly portrayed as binary (female/male or woman/man) and unchangingwhereas these constructs actually exist along a spectrum and include additional sex categorizations and gender identities such as people who are intersex/have differences of sex development (DSD) or identify as non-binary. Moreover, the terms "sex" and "gender" can be ambiguous—thus it is important for authors to define the manner in which they are used. In addition to this definition guidance and the SAGER guidelines, the resources on this page offer further insight around sex and gender in research studies.

Authorship

All authors should have made substantial contributions to all of the following: (1) the conception anddesign of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request sucha change, the Editor must receive the following from the **corresponding author**: (a) the reasonfor the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement ofauthors **after** the manuscript has been accepted. While the Editor considers the request, publicationof the manuscript will be suspended. If the manuscript has already been published in an online issue,any requests approved by the Editor will result in a corrigendum.

Article Transfer Service

This journal is part of our Article Transfer Service. This means that if the Editor feels your article is more suitable in one of our other participating journals, then you may be asked to consider transferring the article to one of those. If you agree, your article will be transferred automatically on your behalfwith no need to reformat. Please note that your article will be reviewed again by the new journal. More information.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has preprinted forms for use by authors in these cases.

For gold open access articles: Upon acceptance of an article, authors will be asked to complete a 'License Agreement' (more information). Permitted third party reuse of gold open access articles is determined by the author's choice of user license.

Author rights

As an author you (or your employer or institution) have certain rights to reuse your work. More information.

Elsevier supports responsible sharing

Find out how you can share your research published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; inthe collection, analysis and interpretation of data; in the writing of the report; and in the decision tosubmit the article for publication. If the funding source(s) had no such involvement, it is recommended to state this.

Open access

Please visit our Open Access page for more information.

Language (usage and editing services)

Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possiblegrammatical or spelling errors and to conform to correct scientific English may wish to use the Language Editing service available from Elsevier's Language Services.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Submit your article

Please submit your article via https://www.editorialmanager.com/dentma/default.aspx.

Suggesting reviewers

Please submit the names and institutional e-mail addresses of several potential reviewers.

You should not suggest reviewers who are colleagues, or who have co-authored or collaborated withyou during the last three years. Editors do not invite reviewers who have potential competing interests with the authors. Further, in order to provide a broad and balanced assessment of the work, and ensure scientific rigor, please suggest diverse candidate reviewers who are located in different countries/

regions from the author group. Also consider other diversity attributes e.g. gender, race and ethnicity,career stage, etc. Finally, you should not include existing members of the journal's editorial team,of whom the journal are already aware.

Note: the editor decides whether or not to invite your suggested reviewers.

PREPARATION

Peer review

This journal operates a double anonymized review process. All contributions will be initially assessedby the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editoris responsible for the final decision regarding acceptance or rejection of articles. The Editor's decisionis final. Editors are not involved in decisions about papers which they have written themselves or havebeen written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. More informationon types of peer review.

Double anonymized review

This journal uses double anonymized review, which means the identities of the authors are concealedfrom the reviewers, and vice versa. More information is available on our website. To facilitate this, please include the following separately:
Title page (with author details): This should include the title, authors' names, affiliations, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.
Anonymized manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.

Use of word processing software

It is important that the file be saved in the native format of the word processor used. The text should be in single-column format. Keep the layout of the text as simple as possible. Most formattingcodes will be removed and replaced on processing the article. In particular, do not use the word processor's options to justify text or to hyphenate words. However, do use bold face, italics, subscripts, superscripts etc. When preparing tables, if you are using a table grid, use only one grid for each individual table and not a grid for each row. If no grid is used, use tabs, not spaces, to align columns.The electronic text should be prepared in a way very similar to that of conventional manuscripts (seealso the Guide to Publishing with Elsevier). Note that source files of figures, tables and text graphics will be required whether or not you embed your figures in the text. See also the section on Electronicartwork.
To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

Article structure

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may begiven a brief heading. Each heading should appear on its own separate line.

Introduction

This must be presented in a structured format, covering the following subjects, although actual subheadings should not be included:

- succinct statements of the issue in question;
- the essence of existing knowledge and understanding pertinent to the issue (reference);
- the aims and objectives of the research being reported relating the research to dentistry, wherenot obvious.

Materials and methods

- describe the procedures and analytical techniques.
- only cite references to published methods.
- include at least general composition details and batch numbers for all materials.
- identify names and sources of all commercial products e.g.

"The composite (Silar, 3M Co., St. Paul, MN, USA)..."
"... an Au-Pd alloy (Estheticor Opal, Cendres et Metaux, Switzerland)."

- specify statistical significance test methods.

Results

- refer to appropriate tables and figures.
- refrain from subjective comments.
- make no reference to previous literature.
- report statistical findings.

Discussion

- explain and interpret data.
- state implications of the results, relate to composition.
- indicate limitations of findings.
- relate to other relevant research.

Conclusion (if included)

- must NOT repeat Results or Discussion
- must concisely state inference, significance, or consequences

Appendices

If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix,Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- ***Author names and affiliations.*** Please clearly indicate the given name(s) and family name(s)of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
- ***Corresponding author.*** Clearly indicate who will handle correspondence at all stages of refereeingand publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
- ***Present/permanent address.*** If an author has moved since the work described in the article wasdone, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Highlights

Highlights are mandatory for this journal as they help increase the discoverability of your article viasearch engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the example Highlights.

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point).

Abstract (structured format)

- 250 words or less.
- subheadings should appear in the text of the abstract as follows: Objectives, Methods, Results, Significance. (For Systematic Reviews: Objectives, Data, Sources, Study selection, Conclusions). TheResults section may incorporate small tabulations of data, normally 3 rows maximum.

Graphical abstract

Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimumof 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 ×13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. You can view Example Graphical Abstracts on our information site.

Highlights are mandatory for this journal. They consist of a short collection of bullet points that convey the core findings of the article and should be submitted in a separate file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point). See https://www.elsevier.com/highlights for examples.

Keywords

Up to 10 keywords should be supplied e.g. dental material, composite resin, adhesion.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first pageof the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and donot, therefore, include them on the title page, as a footnote to the title or otherwise. List here thoseindividuals who provided help during the research (e.g., providing language help, writing assistanceor proof reading the article, etc.).

Formatting of funding sources

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 Institutesof Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. Whenfunding is from a block grant or other resources available to a university, college, or other researchinstitution, 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, ornot-for-profit sectors.

Units

Follow internationally accepted rules and conventions: use the international system of units (SI). Ifother units are mentioned, please give their equivalent in SI.

Math formulae

Please submit math equations as editable text and not as images. Present simple formulae inline with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are oftenmore conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes

Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors can build footnotes into the text, and this feature may be used. Otherwise, please indicate the position of footnotes in the text and list the footnotes themselves separately at the end of the article. Do not include footnotes in the Reference list.

Artwork *Electronic artworkGeneral points*

- Make sure you use uniform lettering and sizing of your original artwork.
- Embed the used fonts if the application provides that option.
- Aim to use the following fonts in your illustrations: Arial, Courier, Times New Roman, Symbol, oruse fonts that look similar.
- Number the illustrations according to their sequence in the text.

- Use a logical naming convention for your artwork files.
- Provide captions to illustrations separately.
- Size the illustrations close to the desired dimensions of the published version.
- Submit each illustration as a separate file.
- Ensure that color images are accessible to all, including those with impaired color vision.

A detailed guide on electronic artwork is available.

You are urged to visit this site; some excerpts from the detailed information are given here.

Formats

If your electronic artwork is created in a Microsoft Office application (Word, PowerPoint, Excel) then please supply 'as is' in the native document format.
Regardless of the application used other than Microsoft Office, when your electronic artwork is finalized, please 'Save as' or convert the images to one of the following formats (note the resolutionrequirements for line drawings, halftones, and line/halftone combinations given below):
EPS (or PDF): Vector drawings, embed all used fonts.
TIFF (or JPEG): Color or grayscale photographs (halftones), keep to a minimum of 300 dpi.
TIFF (or JPEG): Bitmapped (pure black & white pixels) line drawings, keep to a minimum of 1000 dpi.TIFF (or JPEG): Combinations bitmapped line/half-tone (color or grayscale), keep to a minimum of 500 dpi.

Please do not:

- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); these typically have alow number of pixels and limited set of colors;
- Supply files that are too low in resolution;
- Submit graphics that are disproportionately large for the content.

Color artwork

Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF), or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appearin color online (e.g., ScienceDirect and other sites) regardless of whether or not these illustrations are reproduced in color in the printed version. **For color reproduction in print, you will receive information regarding the costs from Elsevier after receipt of your accepted article**. Pleaseindicate your preference for color: in print or online only. Further information on the preparation of electronic artwork.

Captions to tables and figures

- list together on a separate page.
- should be complete and understandable apart from the text.
- include key for symbols or abbreviations used in Figures.
- individual teeth should be identified using the FDI two-digit system.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

References

Must now be given **according to the following numeric system**:

Cite references in text in numerical order. Use square brackets: in-line, not superscript e.g. [23]. All references must be listed at the end of the paper, double-spaced, without indents. For example: 1. Moulin P, Picard B and Degrange M. Water resistance of resin-bonded joints with time related to alloysurface treatments. J Dent, 1999; 27:79-87. 2. Taylor DF, Bayne SC, Sturdevant JR and Wilder AD.Comparison of direct and indirect methods for analyzing wear of posterior composite restorations. Dent Mater, 1989; 5:157-160. Avoid referencing abstracts if possible. If unavoidable, reference as follows: 3. Demarest VA and Greener EH . Storage moduli and interaction parameters of experimentaldental composites. J Dent Res, 1996; 67:221, Abstr. No. 868.

Citation in text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If thesereferences are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Reference links

Increased discoverability of research and high quality peer review are ensured by online links to thesources cited. In order to allow us to create links to abstracting and indexing services, such as Scopus, Crossref and PubMed, please ensure that data provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is highly encouraged.

A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article.An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambeh W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneathnortheastern Venezuela. Journal of Geophysical Research, https://doi.org/10.1029/2001JB000884. Pleasenotetheformat of such citations should be in the same style as all other references in the paper.

Web references

As a minimum, the full URL should be given and the date when the reference was last accessed. Anyfurther information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under adifferent heading if desired, or can be included in the reference list.

Data references

This journal encourages you to cite underlying or relevant datasets in your manuscript by citing themin your text and including a data reference in your Reference List. Data references should include thefollowing elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

Preprint references

Where a preprint has subsequently become available as a peer-reviewed publication, the formal publication should be used as the reference. If there are preprints that are central to your work or thatcover crucial developments in the topic, but are not yet formally published, these may be referenced.Preprints should be clearly marked as such, for example by including the word preprint, or the nameof the preprint server, as part of the reference. The preprint DOI should also be provided.

References in a special issue

Please ensure that the words 'this issue' are added to any references in the list (and any citations inthe text) to other articles in the same Special Issue.

Reference management software

Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley. Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. More information on how to remove field codes from different reference management software.

Reference style

Text: Indicate references by number(s) in square brackets in line with the text. The actual authorscan be referred to, but the reference number(s) must always be given.
List: Number the references (numbers in square brackets) in the list in the order in which they appearin the text.

Examples:

Reference to a journal publication:

[1] Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. J Sci Commun2010;163:51–9. https://doi.org/10.1016/j.Sc.2010.00372.

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.2018;19:e00205. https://doi.org/10.1016/j.heliyon.2018.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 an edited book:

[4] Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, SmithRZ, editors. Introduction to the electronic age, New York: E-Publishing Inc; 2009, p. 281–304. Reference to a website:

[5] Cancer Research UK. Cancer statistics reports for the UK, http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/; 2003 [accessed 13 March 2003].

Reference to a dataset:

[dataset] [6] Oguro M, Imahiro S, Saito S, Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions, Mendeley Data, v1; 2015. https://doi.org/10.17632/ xwj98nb39r.1.

Note 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 forManuscripts submitted to Biomedical Journals' (J Am Med Assoc 1997;277:927–34) (see also Samplesof Formatted References).

Journal abbreviations source

Journal names should be abbreviated according to the List of Title Word Abbreviations.

Video

Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the bodytext where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directlyusable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including ScienceDirect. Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These willbe usedinstead of standardicons and willpersonalize the link to your video data. For more detailed instructions please visit our video instruction pages. Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Supplementary material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the articleand supply a concise, descriptive caption for each supplementary file. If you wish to make changes tosupplementary material during any stage of the process, please make sure to provide an updated file.Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' optionin Microsoft Office files as these will appear in the published version.

Research data

This journal encourages and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refersto the results of observations or experimentation that validate research findings, which may also include software, code, models, algorithms, protocols, methods and other useful materials relatedto the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. If you are sharing data in one ofthese ways, you are encouraged to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing,sharing and using research data and other relevant research materials, visit the research data page.

Data linking

If you have made your research data available in a data repository, you can link your article directly tothe dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect withrelevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For moreinformation, visit the database linking page.

For supported data repositories a repository banner will automatically appear next to your publishedarticle on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Data statement

To foster transparency, we encourage you to state the availability of your data in your submission. This may be a requirement of your funding body or institution. If your data is unavailable to access or unsuitable to post, you will have the opportunity to indicate why during the submission process, for example by stating that the research data is confidential. The statement will appear with your published article on ScienceDirect. For more information, visit the Data Statement page.

AFTER ACCEPTANCE

Online proof correction

To ensure a fast publication process of the article, we kindly ask authors to provide us with their proofcorrections within two days. Corresponding authors will receive an e-mail with a link to our online proofing system, allowing annotation and correction of proofs online. The environment is similar to MS Word: in addition to editing text, you can also comment on figures/tables and answer questionsfrom the Copy Editor. Web-based proofing provides a faster and less error-prone process by allowingyou to directly type your corrections, eliminating the potential introduction of errors.
If preferred, you can still choose to annotate and upload your edits on the PDF version. All instructions for proofing will be given in the e-mail we send to authors, including alternative methods to the onlineversion and PDF.
We will do everything possible to get your article published quickly and accurately. Please use this proof only for checking the typesetting, editing, completeness and correctness of the text, tables and figures. Significant changes to the article as accepted for publication will only be considered at this stage with permission from the Editor. It is important to ensure that all corrections are sent back to us in one communication. Please check carefully before replying, as inclusion of any subsequent corrections cannot be guaranteed. Proofreading is solely your responsibility.

Offprints

The corresponding author will, at no cost, receive 25 free paper offprints, or alternatively a customized Share Link providing 50 days free access to the final published version of the article on ScienceDirect.The Share Link can be used for sharing the article via any communication channel, including email and social media. For an extra charge, paper offprints can be ordered via the offprint order form which is sent once the article is accepted for publication. Corresponding authors who have published their article gold open access do not receive a Share Link as their final published version of the article is available open access on ScienceDirect and can be shared through the article DOI link.

AUTHOR INQUIRIES

Visit the Elsevier Support Center to find the answers you need. Here you will find everything from Frequently Asked Questions to ways to get in touch.
You can also check the status of your submitted article or find out when your accepted article willbe published.