UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE CIÊNCIAS DA SAÚDE
DEPARTAMENTO DE ODONTOLOGIA
CURSO DE ODONTOLOGIA

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Carbonato de Cálcio: uma revisão bibliométrica de aplicações em biomateriais odontológicos

Florianópolis
2025

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Trabalho de Conclusão de Curso submetido ao curso de odontologia do Centro de Ciências da Saúde da Universidade Federal de Santa Catarina como requisito parcial para a obtenção do título de Cirurgiã-Dentista.

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Florianópolis
2025

Oliveira, Samira Schons de
Carbonato de cálcio : Uma revisão bibliométrica de aplicações em biomateriais odontológicos / Samira Schons de Oliveira ; orientador, Sheila Cristina Stolf, coorientador, Andressa da Silva Barboza, 2025.
85 p.

Trabalho de Conclusão de Curso (graduação) - Universidade Federal de Santa Catarina, Centro de Ciências da Saúde, Graduação em Odontologia, Florianópolis, 2025.

Inclui referências.

1. Odontologia. 2. Carbonato de Cálcio. 3. Odontologia. 4. Materiais Biocompatíveis. I. Stolf, Sheila Cristina. II. Barboza, Andressa da Silva . III. Universidade Federal de Santa Catarina. Graduação em Odontologia. IV. Título.

Samira Schons de Oliveira

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Este Trabalho de Conclusão de Curso foi julgado adequado para obtenção do título de Cirurgiã-Dentista e aprovado em sua forma final pelo curso de odontologia.
Florianópolis, 17 de outubro de 2025.

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Florianópolis, 2025.

Dedico este trabalho à minha família, pelo apoio e pela confiança ao longo de toda a minha formação.

AGRADECIMENTOS

Agradeço à minha família, especialmente à minha mãe, Adiles, e à minha irmã, Sandra, pelo amor, apoio e incentivo constantes. Vocês foram fundamentais para minha formação pessoal e profissional, tornando essa conquista ainda mais significativa.

Aos meus tios, Eloi e Franciele, com quem morei durante a graduação, obrigada pelo apoio diário e por me oferecerem um lar que me permitiu focar nos estudos.

À Sheila, minha orientadora, e Andressa, minha coorientadora, sou profundamente grata pela paciência, confiança e dedicação ao longo de todo o trabalho. Seus ensinamentos, apoio e incentivo foram fundamentais e despertaram em mim o interesse pela pesquisa na odontologia.

Agradeço a todos os profissionais que contribuíram para a realização deste trabalho, bem como aos professores do curso de Odontologia da UFSC, pelo conhecimento compartilhado e pelo apoio durante a graduação.

Aos meus amigos, agradeço pela companhia, pelos momentos de descontração e pelo apoio nos momentos mais difíceis.

A todos que, de alguma forma, contribuíram para a realização deste trabalho, registro meu profundo agradecimento.

“A natureza é a fonte de todo conhecimento verdadeiro.”

- Leonardo Da Vinci

RESUMO

O carbonato de cálcio ($CaCO_3$) é um composto utilizado em diversas áreas industriais e biomédicas, devido à sua biocompatibilidade, capacidade de modulação do pH e propriedades remineralizantes. Tradicionalmente, sua obtenção ocorre por meio da mineração de rochas calcárias, um processo de alto consumo energético e significativa emissão de carbono. Recentemente, rotas alternativas e mais sustentáveis vêm ganhando destaque, como a reutilização de resíduos biogênicos, reduzindo o impacto ambiental. Trata-se de um material amplamente empregado na formulação de diversos produtos, com ampla versatilidade e relevância tecnológica. Na odontologia, a valorização de resíduos naturais ricos em $CaCO_3$ para o desenvolvimento de biomateriais sustentáveis representa um novo paradigma que une inovação científica e responsabilidade socioambiental. Essa abordagem está alinhada aos Objetivos de Desenvolvimento Sustentável ao estimular modelos de negócio sustentáveis e promover a circularidade, fomentar bio inovações e reduzir emissões de carbono. Neste contexto, foi realizada uma revisão bibliométrica sobre a aplicação do mineral em biomateriais odontológicos, com o objetivo de mapear o cenário científico e identificar tendências, lacunas e perspectivas futuras. A busca foi realizada na base de dados "*Web of Science*" em março de 2025, sem restrição de idioma ou período de tempo. No total 91 artigos, publicados entre 1953 e 2025 foram incluídos. Entre as informações coletadas estão: autoria, ano e periódico de publicação, fator de impacto, quantidade de citações, desenho de estudo e tema, palavras-chave, instituição e país de origem. O software *VOSviewer* foi utilizado para gerar mapas de redes colaborativas entre os autores e palavras-chave, para análise estatística foi utilizado o teste de correlação de Spearman. O estudo "*Physicochemical study of $CaCO_3$ from egg shells*", de Murakami *et al.* (2007), destacou-se como o mais citado. Quanto ao delineamento metodológico, predominaram estudos *in vitro*, seguidos por ensaios clínicos, refletindo o avanço gradual do conhecimento em direção à aplicabilidade clínica. Geograficamente, os Estados Unidos possuem o destaque em número de publicações, enquanto a Ásia emergiu como o continente com maior produção científica. A Universidade Estadual de Campinas destacou-se como a instituição com o maior número de artigos, evidenciando o potencial da pesquisa brasileira. Entre os periódicos mais representativos, o *American Journal of Dentistry* foi o principal veículo de publicação. As áreas temáticas predominantes foram dentística restauradora e cariologia. A análise das palavras-chave revelou o predomínio de "*calcium carbonate*" e "*hydroxyapatite*". Na origem desse mineral, há o predomínio de materiais comerciais, mas com crescente interesse em fontes sustentáveis, refletindo o alinhamento das pesquisas aos Objetivos do Desenvolvimento Sustentável, voltados ao consumo responsável, mitigação climática e conservação ambiental. Os resultados obtidos demonstram a distribuição global da produção científica e a relevância multifacetada do $CaCO_3$ como biomaterial, com aplicações em diversas especialidades odontológicas, particularmente em estudos laboratoriais sobre implantologia, materiais restauradores e prevenção de cáries. A pesquisa fornece *insights* importantes para pesquisadores que desenvolvem materiais odontológicos inovadores. Contudo, trabalhos futuros nessa temática devem abordar lacunas nas aplicações clínicas e seus resultados à longo prazo.

Palavras-chave: Carbonato de Cálcio; Odontologia; Materiais Biocompatíveis; Materiais Dentários; Remineralização Dental.

ABSTRACT

Calcium carbonate ($CaCO_3$) is a compound widely used in various industrial and biomedical fields due to its biocompatibility, pH-modulating capacity, and remineralizing properties. Traditionally, it is obtained through the mining of limestone, a process with high energy consumption and significant carbon emissions. Recently, alternative and more sustainable routes have gained prominence, such as the reuse of biogenic waste. This material is extensively employed in the formulation of products, highlighting its versatility and technological relevance. In dentistry, the valorization of natural residues rich in $CaCO_3$ for the development of sustainable biomaterials represents a new paradigm that combines scientific innovation and socio-environmental responsibility. This approach aligns with the United Nations Sustainable Development Goals by promoting sustainable business models, circularity, bio-innovation, and carbon emission reduction. In this context, a bibliometric review was conducted on the application of calcium carbonate in dental biomaterials, aiming to map the scientific landscape and identify trends, gaps, and future perspectives. The search was carried out in the Web of Science database in March 2025, without language or time restrictions. In total, 91 articles published between 1953 and 2025 were included. The extracted data comprised authorship, publication year and journal, impact factor, citation count, study design and topic, keywords, institution, and country of origin. The VOSviewer software was used to generate collaboration and keyword network maps, and Spearman's correlation test was applied for statistical analysis. The study "Physicochemical study of $CaCO_3$ from egg shells" by Murakami et al. (2007) stood out as the most cited. Regarding the methodological design, in vitro studies predominated, followed by clinical trials, reflecting the gradual advancement of knowledge toward clinical applicability. Geographically, the United States led in the number of publications, while Asia emerged as the continent with the highest scientific output. The State University of Campinas was identified as the institution with the greatest contribution, highlighting the strength of Brazilian research in the field. Among the most representative journals, the American Journal of Dentistry was the main publication outlet. The most frequent thematic areas were restorative dentistry and cariology. Keyword analysis revealed the predominance of "calcium carbonate" and "hydroxyapatite". Regarding the origin of the mineral, most studies used materials from commercial sources, although there is growing interest in sustainable alternatives, reflecting the alignment of current research with the Sustainable Development Goals, particularly those addressing responsible consumption, climate mitigation, and environmental conservation. Overall, the scientific landscape on calcium carbonate in dental biomaterials has evolved to integrate materials science, sustainability, and clinical innovation, reinforcing dentistry's role in advancing both oral health and sustainable development. The findings demonstrate the global distribution of scientific production and the multifaceted relevance of $CaCO_3$ as a biomaterial, with applications across various dental specialties, particularly in laboratory studies focusing on implantology, restorative materials, and caries prevention. This research provides important insights for researchers developing innovative dental materials. However, future work in this field should address gaps in clinical applications and long-term outcomes.

Keywords: Calcium Carbonate; Dentistry; Biocompatible Materials; Dental Materials; Tooth Remineralization.

LISTA DE ABREVIATURAS E SIGLAS

$CaCO_3$	Carbonato de Cálcio
$NCaCO_3$	Carbonato de Cálcio nanoestruturado
VOSviewer	Software Visualization of Similarities Viewer
WoS-CC	Web of Science Core Collection
ONU	Organização das Nações Unidas

SUMÁRIO

1 INTRODUÇÃO

O carbonato de cálcio ($CaCO_3$) é um dos materiais mais abundantes na crosta terrestre, amplamente encontrado na natureza, presente em rochas e minerais, como calcário, gesso, mármore e sedimentos marinhos. Macroscopicamente, o material se apresenta como um pó fino, branco, inodoro, insípido e microcristalino. Além de sua ocorrência geológica, também está presente em organismos vivos, integrando estruturas de suporte e proteção em animais e plantas marinhas (Niu *et al*., 2022; Omari *et al.*, 2016).

O $CaCO_3$ apresenta três formas cristalinas polimórficas: vaterita (hexagonal), aragonita (ortorrômbica) e calcita (romboédrica), sendo essa a mais estável termodinamicamente. Existem também formas hidratadas, como a monohidrocalcita ($CaCO_3 \cdot H_2O$), a ikaíta ($CaCO_3 \cdot 6H_2O$) e a forma hemidratada $CaCO_3 \cdot ½H_2O$. Destaca-se ainda uma forma amorfa e instável, conhecida como carbonato de cálcio amorfo (ACC), encontrada em alguns organismos marinhos, como corais do gênero *Stylophora pistillata* e ouriços-do-mar (Niu *et al*., 2022). A ampla diversidade de origens, morfologias, composições e formas cristalinas do carbonato de cálcio evidencia o enorme potencial para aplicações tecnológicas, além de torná-lo um material de grande interesse para pesquisas em diversas áreas científicas. O uso do carbonato de cálcio não é recente, mas os avanços na nanotecnologia e na ciência dos materiais têm renovado o interesse pelo composto (Niu *et al*., 2022).

Na forma de nanopartículas, apresenta ótimas propriedades mecânicas, maior bioatividade e capacidade de biodegradação. Na área biomédica, pesquisadores investigam a aplicação de nanopartículas associadas a medicamentos, avaliando seu potencial uso em quimioterapia, terapia genética e imunoterapia (Qi *et al., 2018;* Zhao *et al., 2022)*. Por ser biocompatível e biodegradável, o $CaCO_3$ é considerado um dos biomateriais mais seguros, pois seus produtos de degradação, íons cálcio (Ca^{2+}) e carbonato (CO_3^{2-}), já estão naturalmente presentes no organismo. Além disso, o material é estável em pH fisiológico (7,4) e se decompõe rapidamente em ambientes ácidos como o microambiente de tumores, favorecendo a liberação direcionada de medicamentos, como a doxorrubicina às células tumorais. Ao se decompor, libera nanobolhas de CO2 que se unem formando microbolhas, contribuindo para a manutenção de um

sinal ecogênico forte. O carbonato também é utilizado como base para agentes de contraste aprimorados para aumentar a distinção entre os tecidos tumorais e saudáveis (Huang *et al., 2020;* Qi *et al., 2018;* Zhao *et al., 2022)*. Trata-se de um material de extrema relevância, amplamente empregado na fabricação de diversos produtos industriais. É utilizado como aditivo em plásticos e gomas de mascar, está presente na formulação de tintas, papéis e adesivos, assim como em dentifrícios e cosméticos (Horie *et al., 2014;* Wannakajeepiboon *et al.,* 2023*).*

Tradicionalmente, a obtenção do carbonato de cálcio ocorre por meio da mineração de rochas, um processo associado ao alto consumo energético e com significativa emissão de CO_2 (Ganapathi, 2020; Enemuo; Ogunmodimu, 2025). Recentemente, alternativas mais sustentáveis vêm sendo exploradas. A reutilização de resíduos biogênicos como conchas de moluscos e ostras descartadas pela maricultura surgem como alternativas promissoras, essa prática não apenas mitiga o impacto ambiental e fortalece a economia circular, mas também se alinha com os princípios da Agenda 2030 da ONU (Organização das Nações Unidas) para o Desenvolvimento Sustentável. Ao transformar um passivo ambiental em produtos de alto valor agregado, como pastas de microabrasão, medicações intracanal e membranas de nanofibras, redimensiona-se o potencial do $CaCO_3$ na odontologia, conciliando inovação tecnológica com responsabilidade socioambiental.

Esse potencial é vasto e cientificamente respaldado. Na prática clínica, o carbonato de cálcio apresenta aplicações que abrangem desde a dentística restauradora até terapias regenerativas, mostrando grande eficácia no enfrentamento de desafios como desmineralização do esmalte, a hipersensibilidade dentinária e a osteointegração de implantes dentais (Cury *et al., 2003;* Hsu, Lee, Chang, 2013; Liu *et al.*, 2011). Esse mineral é um dos abrasivos mais utilizados em cremes dentais, auxiliando na remoção da placa bacteriana. Possui capacidade de neutralizar ácidos na cavidade oral, aumenta o nível de cálcio da placa bacteriana e atua como reservatório de cálcio durante o processo de remineralização. A capacidade do $CaCO_3$ de reservar e liberar íons de cálcio forma uma camada protetora sobre a dentina exposta, sendo um componente promissor em produtos para o tratamento da hipersensibilidade dentinária, promovendo o bloqueio dos túbulos dentinários e reduzindo a transmissão de estímulos dolorosos para a polpa dental (Chen *et al.,* 2024*)*.

A trajetória científica do carbonato de cálcio na saúde bucal, iniciada com os achados de Gore em 1953 sobre sua importância na prevenção de cáries, foi consolidada por descobertas subsequentes. Nos anos 2000 Cury *et al.* (2003) constatou que a incorporação do mineral em dentifrícios elevou a microdureza superficial e foi mais eficaz na remineralização do esmalte em comparação ao grupo controle, na mesma época, o estudo elaborado por Lynch e Cate (2005) relatou que o uso de creme dental contendo carbonato de cálcio tem potencial para reduzir significativamente a acidez do biofilme bacteriano. Recentemente, Mahmoud *et al.* (2024) comprovou que uma formulação com $CaCO_3$ proporcionou melhor recuperação da microdureza e redução na profundidade das lesões após um ciclo de tratamento remineralizante. Além disso, em um avanço notável, o uso isolado do carbonato de cálcio foi capaz de reduzir a formação de biofilme por *Streptococcus mutans* na dentina (Chen *et al.,* 2024*).*

Na endodontia, o estudo de Wannakajeepiboon *et al.* (2023) demonstrou a eficácia das conchas de berbigão como fonte alternativa e sustentável de carbonato de cálcio para a formulação de cimento endodôntico (*BioCement*). O material desenvolvido apresentou propriedades físico-químicas adequadas, posicionando-se como uma opção promissora com menor custo e impacto ambiental em comparação à extração mineral convencional.

Na área de implantes dentários, evidências de estudos *in vivo* indicam que o revestimento de carbonato de cálcio na superfície de implantes de titânio é capaz de induzir a diferenciação celular para fenótipos osteoblásticos. Esse efeito é atribuído principalmente à rugosidade superficial proporcionada pelo revestimento e à liberação de íons cálcio (Liu *et al.*, 2011). Na Periodontia, o $CaCO_3$ também demonstra potencial para aplicação em estratégias de regeneração tecidual, destacando-se no tratamento de defeitos ósseos associados à doença periodontal, o material é biocompatível e sua reabsorção gradual é acompanhada pela neoformação óssea (Mora; Ouhayoun, 1995).

A análise bibliométrica, baseada em técnicas quantitativas, mapeia a produção científica para fornecer uma visão abrangente de um determinado campo de estudo. Essa abordagem não só identifica lacunas de conhecimento e aponta tópicos emergentes, como também estimula novas pesquisas, ajudando os pesquisadores a se alinharem com as tendências atuais. O crescente número de

estudos bibliométricos observados nos é impulsionado por fatores como a popularização de softwares especializados, o interesse econômico inerente à síntese de grandes volumes de dados científicos e o potencial dessas análises para gerar pesquisas de alto impacto (Donthu *et al*., 2024).

Além de avaliar a relevância e o impacto de trabalhos e áreas de estudo específicas, a bibliometria tornou-se uma ferramenta estratégica ao auxiliar na orientação de políticas de pesquisa, no estabelecimento de prioridades acadêmicas e na definição de estratégias de financiamento, consolidando-se como elemento essencial para o avanço e direcionamento eficiente da ciência (Donthu *et al*., 2024).

Nesse contexto, a análise bibliométrica mostra-se uma ferramenta particularmente valiosa para investigar campos de conhecimento cuja produção científica é dispersa e pouco consolidada, como é o caso do aplicação do carbonato de cálcio ($CaCO_3$) em biomateriais odontológicos. Apesar do interesse crescente e das vantagens promissoras ilustradas pela literatura, o conhecimento sobre o tema permanece fragmentado em estudos isolados, que focam em aspectos diversos e desconectados de suas aplicações. Portanto, realizar um mapeamento bibliométrico torna-se essencial para sintetizar esse panorama fragmentado, identificar as principais tendências e lacunas, e consolidar as bases para futuras pesquisas nessa área emergente.

A ausência de uma visão estruturada sobre as tendências emergentes e as lacunas de conhecimento científico tem limitado o progresso da pesquisa e o desenvolvimento de novos produtos clínicos na odontologia. Para enfrentar esse desafio, este estudo propõe uma revisão bibliométrica com o objetivo de fornecer uma análise abrangente da aplicação do carbonato de cálcio na área. Ao mapear o cenário científico, busca-se elucidar as potencialidades e os principais desafios a serem enfrentados em investigações futuras. Espera-se que os resultados amparem pesquisadores, profissionais da saúde e a indústria, não apenas fundamentando decisões baseadas em evidências, mas também impulsionando o desenvolvimento e a adoção de materiais inovadores e eficazes voltados à promoção da saúde bucal.

2 OBJETIVOS

2.1 OBJETIVO GERAL

O presente trabalho buscou, por meio de uma revisão bibliométrica, analisar, quantificar e documentar a produção científica mundial e as tendências de pesquisa dos artigos publicados até março de 2025 a respeito da aplicação de Carbonato de Cálcio em biomateriais odontológicos.

2.2 OBJETIVOS ESPECÍFICOS

- Identificar as palavras-chave mais utilizadas;
- Avaliar os principais pesquisadores na área;
- Analisar os periódicos com maior frequência de publicação sobre o tema;
- Verificar a tendência de crescimento das pesquisas nos últimos anos;
- Estabelecer quais instituições mais fomentam a produção científica sobre a temática;
- Avaliar e comparar a quantidade de citações dos artigos entre diferentes bases de dados;
- Analisar os países e continentes com maior número de publicações na área;
- Examinar os desenhos de estudo e as temáticas mais recorrentes;
- Identificar as áreas e subáreas de aplicação do $CaCO_3$ na Odontologia.

3 ARTIGO

Este trabalho encontra-se nas normas da revista "*Journal of Applied Oral Science*", sob o DOI:10.1590/1678-7757-2025-0287. Este periódico adota o modelo de Acesso Aberto (Open Access), disponibilizando seus artigos gratuitamente na internet. Sob a licença Creative Commons Atribuição (CC-BY), o periódico concede a qualquer usuário o direito de ler, baixar, copiar, distribuir e utilizar o conteúdo para quaisquer fins legítimos, desde que devidamente atribuída a autoria,. O artigo pode ser acessado em: https://www.scielo.br/j/jaos/a/vMQnH9VJP7BNxfZj9MgNYxt/?lang=en.

Calcium carbonate in dentistry: a bibliometric review of emerging applications and trends

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Received: May 01, 2025
Revised: August 18, 2025
Accepted: August 18, 2025

Abstract

Calcium carbonate ($CaCO_3$) has garnered increasing attention in dental research due to its versatile bioactive properties and expanding applications in preventive, restorative, and regenerative therapies.

Objective: This study aims to comprehensively assess the bibliometric features of articles evaluating the utilization of calcium carbonate ($CaCO_3$) in dentistry by conducting a bibliographic search on the Web of Science databases until March 2025. Methodology: The following data were collected: number and density of citations; authorship; year, journal of publication, and impact factor; study design and theme; keywords; institution and country of origin. VOSviewer software was used to generate collaborative network maps for authors and keywords. Results: A total of 91 highly cited articles were identified, with citation counts ranging from 123 to zero.

Most articles (74%) were published after 2010, with the highest prevalence in Asia (44%), especially China (10%). The most frequent study design was in vitro (55%), primarily focused on restorative dentistry (29%) and cariology (23%). The most common keywords were “Calcium Carbonate” and “Hydroxyapatite”. DeVizio W. was the most prolific author, with four publications. Conclusions: Bibliometric analysis highlights a growing interest in the application of calcium carbonate in dentistry, with a progressive increase in scientific output over the years. The findings underscore the global distribution of research and emphasize the relevance of this biomaterial in various dental specialties. This study reinforces several key points for research groups worldwide engaged in the development of innovative dental materials, providing valuable direction for future investigations, which remain limited in scope, especially regarding clinical applications and long-term outcomes.

Keywords: Calcium Carbonate. Dentistry. Biocompatible Materials. Dental Materials. Tooth Remineralization.

Calcium carbonate in dentistry: A bibliometric review of emerging applications and trends

Introduction

Calcium carbonate ($CaCO_3$) has emerged as a transformative biomaterial in modern dentistry, bridging the gap between fundamental material science and clinical innovation. As the most stable crystalline polymorph of calcium-based minerals, $CaCO_3$ exhibits exceptional biocompatibility, pH-modulating capacity, and osteoconductive properties—attributes that have propelled its integration into preventive, restorative, and regenerative dental therapies.[1-3] The mineral's unique capacity to undergo phase transitions between calcite, aragonite, and vaterite forms allows precise tuning of its mechanical and dissolution kinetics, making it indispensable for applications ranging from bioactive fillers to drug-eluting scaffolds.[4-6] With dental caries and periodontal diseases affecting 3.5 billion people globally,[7] $CaCO_3$'s multifaceted functionality addresses urgent unmet needs in oral healthcare, particularly in minimally invasive and sustainable treatment paradigms.

The renaissance of $CaCO_3$ in dentistry is driven by nanotechnology-enabled breakthroughs. Nano-structured $CaCO_3$ ($nCaCO_3$) demonstrates superior bioactivity compared to conventional micron-sized particles, with 40–60% higher remineralization efficiency in demineralized enamel.[8] This enhancement stems from $nCaCO_3$'s increased surface area and ion release kinetics, which facilitate rapid apatite nucleation.[9] Clinically, $nCaCO_3$-doped composites exhibit 30% greater compressive strength than commercial controls,[2,9] while $CaCO_3$-infused dentifrices reduce secondary caries incidence by 22% over 2-year follow-ups.[8,10,11] Furthermore, $CaCO_3$'s synergy with fluoride and antimicrobial agents has yielded next-generation formulations that simultaneously disrupt biofilms, buffer acidic challenges, and promote mineral gain—a triadic mechanism critical for caries management in high-risk populations.[3,12,13]

Beyond prevention, $CaCO_3$ is redefining regenerative dentistry. As a scaffold component, its interconnected porosity, large surface area, and controlled degradation kinetics support angiogenesis and osteogenesis.[2,9] The mineral's intrinsic immunomodulatory properties further enhance healing, significantly reducing pro-inflammatory cytokines (IL-6, TNF-α) in periodontal defects.[14] Recent advances exploit $CaCO_3$ as a stimuli-responsive carrier, where pH-triggered release of

antibiotics (e.g., doxycycline) achieves localized, sustained antimicrobial activity at periodontal pockets—a paradigm shift from systemic dosing.[2,14] Such innovations underscore $CaCO_3$'s potential to revolutionize personalized and precision dentistry.

Bibliometric analysis represents a powerful tool for mapping the evolution of scientific fields, offering quantitative insights into research trends, collaborative networks, and emerging frontiers.[15] In this context, the applications of calcium carbonate ($CaCO_3$) in dentistry are particularly salient, given the material's expanding role across preventive, restorative, and regenerative therapies. By systematically analyzing publication patterns, this methodology can reveal critical shifts in research priorities—from early explorations of $CaCO_3$'s abrasive properties to contemporary investigations into its nanostructured formulations and bioengineered composites. Moreover, bibliometric techniques enable the identification of underserved research areas, such as the long-term clinical performance of $CaCO_3$-based materials or their interactions with the oral microbiome, which remain poorly characterized despite their clinical relevance.

To date, no comprehensive bibliometric assessment has been conducted to synthesize the global research landscape of $CaCO_3$ in dental science. This gap impedes efforts to optimize resource allocation, foster cross-disciplinary collaboration, and accelerate the translation of laboratory innovations into clinical practice. The present study addresses this need by employing rigorous bibliometric methods to evaluate the scientific output related to $CaCO_3$ in dentistry, with particular attention to thematic evolution, geographic distribution of knowledge production, and the interplay between material science and clinical research. Specifically, it seeks to identify the most influential publications, emerging thematic areas, and global contributors, while highlighting underexplored topics such as clinical translation and long-term outcomes. By doing so, this bibliometric analysis is expected to support more informed decision-making among researchers, funding bodies, and dental biomaterials developers. Furthermore, delineating these dimensions provides a foundational framework for future investigations and highlights opportunities to bridge existing gaps between fundamental research and applied dental medicine. The findings are expected to inform strategic decision-making for researchers, funding agencies, and industry partners invested in advancing oral biomaterials. Furthermore, by delineating these dimensions.

Methods

Data Collection

The bibliometric review methodology followed established models proposed by Donthu et al.[16] (2021) and dos Anjos et al.[17] (2023), and the protocol was registered on the Open Science Framework (DOI: 10.17605/OSF.IO/C2TVZ). A comprehensive search was conducted in the Web of Science Core Collection (WoS-CC) database (https://www.webofscience.com) on March 29, 2025, using the institutional access provided by the Federal University of Santa Catarina. The search strategy (Table 1) was designed to identify publications addressing calcium carbonate ($CaCO_3$) in dental contexts. No filters were applied regarding language or publication date. Only original research articles and review papers were included, while conference abstracts and non-dental regenerative studies were excluded.

Table 1- Search strategy for $CaCO_3$ in dental applications on Web of Science (WoS)

Search Strategy	Keywords
Calcium Carbonate Variants	"calcium carbonate" OR "CaCO3" OR "limestone" OR "aragonite" OR "calcite" OR "vaterite"
Dental Applications	"dental applications" OR "dentistry" OR "dental materials" OR "dental" OR "dental therapy" OR "dental restorations" OR "dental sealers" OR "dental implants" OR "endodontics" OR "periodontics" OR "orthodontics" OR "enamel repair" OR "dentin regeneration" OR "tooth remineralization" OR "dental caries" OR "tooth repair" OR "stomatology" OR "dental radiology" OR "pediatric dentistry" OR "dental care for children" OR "preventive dentistry" OR "dental sealants" OR "dental, oral and maxillofacial”
Combined Query	TS=("calcium carbonate" OR "CaCO3" OR "limestone" OR "aragonite" OR "calcite" OR "vaterite") AND TS=("dental applications" OR "dentistry" OR "dental materials" OR "dental" OR "dental therapy" OR "dental restorations" OR "dental sealers" OR "dental implants" OR "endodontics" OR "periodontics" OR "orthodontics" OR "enamel repair" OR "dentin regeneration" OR "tooth remineralization" OR "dental caries" OR "tooth repair" OR "stomatology" OR "dental radiology" OR "pediatric dentistry" OR "dental care for children" OR "preventive dentistry" OR "dental sealants" OR "dental, oral and maxillofacial")

Data Screening

All identified articles were independently screened by two reviewers (APVBM and SCS), who evaluated titles, abstracts, and, when necessary, the full texts using

the Rayyan platform for systematic reviews. The exclusion criteria were: (1) studies that did not involve the application of $CaCO_3$ in Dentistry; and (2) materials that promoted the formation of calcium carbonate in situ rather than containing pre-formed $CaCO_3$. Studies where $CaCO_3$ was part of a formulation but not explicitly mentioned in the title/abstract were systematically excluded. Discrepancies between reviewers were resolved through discussion and consensus with a third reviewer (ABS). This dual-reviewer approach was implemented to enhance screening reliability and minimize the risk of selection bias, in accordance with best practices in evidence-based reviews. Blinded (double) screening was implemented using the blinding function available in Rayyan (https://new.rayyan.ai/), ensuring that each reviewer was unaware of the other's decisions during the initial selection phase. This methodological choice was adopted to minimize selection bias and enhance objectivity. All reviewers received standardized training prior to the screening phase. Inter-rater agreement was evaluated using Cohen's kappa coefficient ($\kappa = 0.82$), indicating strong agreement between the reviewers. A flow diagram of the study selection process is presented in Figure 1.

Data Import and Processing

The final dataset of included literature was imported into Rayyan to identify and remove duplicate records. Data processing involved both automated screening provided by the platform and manual verification. To ensure accuracy and reproducibility, two independent reviewers participated in the data extraction and classification process, combining automated and manual methods to minimize errors and enhance reliability. The extracted bibliometric data included the title, authors, year and journal of publication, total number of citations and citation density (citations per year in WoS-CC), institution, country and continent of origin (based on the affiliation of the corresponding author), journal impact factor for the year 2024 (according to Journal Citation Reports), keywords, study design, and research topic. Study designs were classified into the following categories: in vitro, in vivo, in situ, combined in vitro/in vivo, in situ/ex vivo, clinical/in vitro, reviews, and clinical studies. Given the scope of the study, the included articles were also categorized according to the most prevalent dental topics, as listed below: cariology, endodontics, pharmacology, dental materials, operative dentistry, implant dentistry, preventive

dentistry, regenerative dentistry, restorative dentistry, periodontics, and prosthodontics.

Bibliometric Network Analysis

To further explore thematic trends and author collaborations, the most frequent keywords and contributing authors were identified using the Visualization of Similarities Viewer (VOSviewer, version 1.6.17.0, The Netherlands). All data were manually verified by two independent reviewers (ASB and SSO). VOSviewer was also used to generate graphical representations of bibliometric networks, illustrating the relationships between authors (considering only those with at least two occurrences) and highlighting prominent keywords (considering only those with at least four occurrences). Keywords displayed in larger fonts and colored red/orange represented the most frequently used terms, whereas keywords shown in green/blue denoted less frequent terms. In the author network visualization (for authors with four or more occurrences), those connected and sharing the same color were part of collaborative clusters. Authors represented by larger circles had a higher number of publications. In the network analysis, clusters consisted of closely related nodes, each identified by a specific color. The node size corresponded to the total number of publications by each co-author. Larger circles indicated more relevant terms, and highly related terms were positioned closer together. The connecting lines between terms represented the strength of their association, with thicker lines indicating stronger links. In the density map, terms with greater emphasis and intensity of color (closer to red) indicated higher occurrence or correlation, while those with lighter colors (yellow or green) suggested lower frequency or relevance.

Statistical Analysis

Spearman’s correlation analysis was performed to evaluate the relationship between the number of citations, journal impact factor (IF), and year of publication. Prior to the analysis, the Kolmogorov–Smirnov test was applied to assess data normality, which indicated non-normal distributions for all variables. Given this result and the exploratory nature of the study, Spearman’s rank correlation coefficient was selected as a robust non-parametric method suitable for identifying monotonic relationships. Adjusted regression models were not applied due to the limited number of independent variables and the descriptive scope of this bibliometric analysis. All

statistical procedures were performed using SPSS for Windows (version 24.0; IBM Corp).

Language and writing assistance

To improve the clarity and quality of the English writing, artificial intelligence tools were used during the manuscript preparation. These included Grammarly® (Grammarly Inc., USA), ChatGPT (OpenAI, USA), and DeepSeek (DeepSeek, China), which assisted in grammar correction, language refinement, and improvement of scientific writing style. All content was critically reviewed and validated by the authors to ensure accuracy and originality.

Results

Search Results

The search strategy identified 493 publications. Potential articles related to calcium carbonate use in dentistry were screened by reviewing titles and abstracts for relevance to the research objectives. During this process, 402 documents were excluded for not aligning with the study aims or for using calcium carbonate-inducing materials rather than pre-formed calcium carbonate. Additional articles were excluded due to non-dental applications of calcium carbonate. In total, 91 articles were included and categorized by study type: in vitro studies (n=50) were the most prevalent, followed by clinical trials (n=24), in vivo studies (n=8), literature reviews (n=3), and in situ (n=2). Four additional studies employed combined methodologies: two using in vivo/in vitro designs (n=2), one clinical/in vitro (n=1), and one combining in situ/ex vivo approaches (n=1).

Citation Analysis

The analyzed studies received a total of 1,597 citations in the Web of Science Core Collection (WoS-CC) database, with citation counts ranging from 123 to 0 (Supplementary Table 1). The ten most-cited articles each accumulated over forty citations (Figure 2). The most cited article (123 citations) was "*Physicochemical study of $CaCO_3$ from egg shells*", an in vitro study published by Murakami et al.[18] (2007) in Ciência e Tecnologia de Alimentos, with an average annual citation rate of

approximately 7. The second most cited article received 115 citations: "*Physicochemical Characterization of Biomaterials Commonly Used in Dentistry as Bone Substitutes - Comparison with Human Bone*", another in vitro study by Figueiredo, et al.[19] (2010) published in the Journal of Biomedical Materials Research Part B: Applied Biomaterials, showing an average of about 8 citations per year. The third most cited work was Kraivaphan et al.[10] (2013) clinical study titled "*Two-Year Caries Clinical Study of the Efficacy of Novel Dentifrices Containing 1.5% Arginine, an Insoluble Calcium Compound and 1,450 ppm Fluoride*", published in Caries Research, which garnered 70 citations with an average of approximately 6 annual citations.

Publication Year Analysis

The timeline of publications spans from the earliest available study—Gore [20] (1953) article "*The role of calcium carbonate in dental caries*"—to the most recent work by Xue Chen, et al.[14] (May 2025) titled "*NIR-responsive $CaCO_3$@BMP-2/PDA nanocomposite for multifunctional therapy in periodontitis*". The most highly cited articles were published between 1996 (n=56 citations) and 2018 (n=41 citations), collectively accounting for 42.18% of total citations (n=1,597). Figure 3 illustrates the relationship between publication year and citation frequency, demonstrating the evolving impact of $CaCO_3$ research in dental science.

Contributing Journals and Impact Factor

The journals with the highest publication output on calcium carbonate in dentistry are presented in Table 2. American Journal of Dentistry led with the most publications (8 articles, 9% of total), accumulating 82 citations in WoS-CC, followed by Caries Research (6 articles, 7%) with 200 citations, and BMC Oral Health (4 articles, 5%) with 8 citations. Regarding 2024 impact factors, the highest-ranking journals were Biomaterials (IF 12.8), International Journal of Oral Science (IF 10.8), and Materials Science & Engineering C: Materials for Biological Applications (IF 8.1).

Table 2- Journals that published the most on $CaCO_3$ in dentistry.

Source title	Number of papers	Impact factor

American Journal of Dentistry	08	0.9
Caries Research	06	2.9
BMC Oral Health	04	2.6
Journal of Periodontology	03	4.2
Dental Materials Journal	03	1.9
Materials Science & Engineering C – Materials for Biological Applications	02	8.1
Ceramics International	02	5.1
Nanomaterials	02	4.4
Journal of Biomedical Materials Research Part B – Applied	02	3.2
International Dental Journal	02	3.2

Study Design, Research Topics, Fields of Application, and $CaCO_3$ Utilization

The majority of articles were in vitro studies (n=50, 735 citations), followed by clinical studies (n=24, 515 citations), in vivo studies (n=8, 169 citations), literature reviews (n=3, 68 citations), in situ studies (n=2, 89 citations), and combined methodologies: in vitro/in vivo (n=2, 2 citations), clinical/in vitro (n=1, 1 citation), and in situ/ex vivo (n=1, 18 citations) (Figure 1). Laboratory studies were predominantly conducted in China (n=9), India (n=5), Japan (n=5), and the USA (n=5) (Figure 4).

The articles covered various areas of application within dentistry, with a focus on restorative dentistry (26 articles), cariology (21 articles), and implantology (18 articles). Other relevant areas included endodontics (7 articles), operative dentistry (6 articles), and periodontology (5 articles). Topics such as dental materials (2 articles), preventive dentistry (2 articles), and regenerative dentistry (2 articles) were also discussed. Additionally, areas like pharmacology (1 article) and prosthodontic dentistry (1 article) were mentioned, albeit less frequently. This overview reflects the diversity of topics addressed in the literature, with an emphasis on areas directly related to dental treatment and rehabilitation.

Based on the analysis of the frequency with which each application of $CaCO_3$ was mentioned, a quantitative distribution that highlights its versatility in dentistry can be observed. The most frequent application was caries prevention, recorded in 18 instances, followed by dentin hypersensitivity control, mentioned 16 times. Bone and dental regeneration had 13 occurrences, while dental implants were mentioned 12

times. Dental materials appeared 9 times, and antimicrobial effects, as well as dental calculus prevention, appeared in 5 instances each. Other applications include studies on tooth brushing abrasion, osteogenic differentiation, mechanical properties, whitening, biomimetics, and material for pulp capping, with 2 articles each. Less frequent uses for calcium carbonate include use in endodontic cement, hard tissue remineralization, and as an excipient in pharmacology, with 1 occurrence each. These data highlight the wide range of functions of $CaCO_3$, emphasizing its relevance in both functional aspects and regenerative and protective approaches within modern dental practice.

$CaCO_3$-Based Materials and Applications

Regarding the origin of the $CaCO_3$, a total of 55 entries referred to commercial products, representing the most frequently reported category. Naturally derived materials were also common, with the highest frequency observed for eggshells (n=6), followed by mollusk shells (n=2), cuttlefish bone (n=1), and equisetum grass (n=1). On one occasion, the mineral was isolated and characterized from oral bacteria Paenibacillus sp. (n=1). Synthetic or laboratory-synthesized materials were reported in 8 instances. Materials with unspecified origin totaled 14, and 3 entries were classified as not applicable.

Among the materials described, dentifrices predominated (31 records), confirming their widespread use in oral care products. This was followed by desensitizing pastes (8 mentions) and bone graft materials/substitutes (6 mentions), highlighting their relevance in regenerative and orthopedic applications. Other reported materials included abrasives (5 mentions) and specialized categories such as scaffolds, pulp capping agents, nanoparticles, and biomaterials. The diversity of $CaCO_3$-based materials—including composites, bioceramics, nanofibers, hydrogels, and porous structures—demonstrates the increasing sophistication and versatility of mineral-based approaches in dentistry, aligning with contemporary trends in tissue engineering and minimally invasive therapies.

Global Research Landscape

The scientific literature on calcium carbonate ($CaCO_3$) applications in dentistry encompassed contributions from 30 countries, demonstrating the material's global research significance. Leading contributors included the United States (13

publications, 221 citations), China (9 articles, 111 citations), Brazil (6 articles, 219 citations), and India (7 articles, 34 citations). Additional participating nations comprised Japan, Italy, South Korea, Taiwan, United Kingdom, Australia, Iran, Egypt, Switzerland, Thailand, Indonesia, Germany, Mexico, Argentina, Portugal, France, Hungary, Malaysia, South Africa, Qatar, Romania, Finland, Spain, Turkey, Russia, and Serbia.

Continental analysis revealed Asia as the most productive region (40 articles, 440 citations), followed by Europe (22 articles, 576 citations) and Anglo-Saxon America (15 articles, 236 citations). Latin America contributed 7 publications, while Africa and Oceania accounted for 4 and 3 publications, respectively. This geographical distribution, illustrated in Figure 4, underscores the multinational and interdisciplinary nature of contemporary $CaCO_3$ research in dental applications.

Contributing Institutions

Among 145 institutions publishing on dental $CaCO_3$ applications, the most productive were: State University of Campinas (4 articles), followed by Loma Linda University, Wuhan University, Egyptian Knowledge Bank, and Colgate-Palmolive Company (3 articles each). Institutions with equivalent publication counts were ranked by their cumulative citation counts in Web of Science (Table 3). This ranking highlights both academic and industry leaders driving innovation in calcium carbonate dental research.

Table 3- Institutions with the highest number of publications on CaCO3 in dentistry.

Institutions	Number of articles	Number of citations
State University of Campinas	4	78
Loma Linda University	3	97
Wuhan University	3	67
Egyptian Knowledge Bank (EKB)	3	21
Colgate-Palmolive Company	3	14
University of Melbourne	2	56
Unilever	2	53
Kasetsart University	2	29
Voronezh State University	2	20
University of Belgrade	2	16

Keywords

The criterion of at least several co-occurrences identified clinical evaluation (frequently cited), calcium carbonate, and hydroxyapatite as core materials of interest across studies (Figure 5). Application-focused terms such as implants, dentistry, caries, and toothpaste appeared consistently, highlighting the emphasis on regenerative and preventive dental care. Additional frequently mentioned keywords included membranes, scaffold, phosphate, and fabrication, often linked to biomaterial development and dental tissue engineering. The presence of pH changes and dentifrice suggests a strong connection with oral environment modulation.

Contributing Authors

The bibliometric analysis identified the involvement of 472 authors in the evaluated body of scientific literature. Among them, DeVizio W emerged as the most prolific contributor, with four published articles, followed by Mateo LR and Zhang YP, each with three publications. Figure 6 illustrates the collaborative relationships among researchers, while Table 4 ranks the top 10 authors with the highest contributions to this field of study.

Table 4- Authors with the highest number of publications on CaCO3 in dentistry.

Authors	Number of papers	Number of citations
DeVizio W	4	104
Mateo LR	3	77
Zhang YP	3	77
Cummins D	2	73
Cury JA	2	64
Fernando JR	2	56
Jiang, T	2	56
Baines E	2	30
Goloshchapov, D	2	20
Kashkarov, V	2	20

Correlation Analysis

Descriptive statistics for citation count, citation density, and year of publication are shown in Table 5. The average number of citations per article was 17.0 (SD = 22.3), with a median of 10, while density ranged from 0.00 to 8.50 citations/year. The Shapiro–Wilk test indicated that all variables deviated significantly from a normal distribution ($p < 0.001$), justifying the use of non-parametric correlation analysis

Table 5- Descriptive statistics of bibliometric variables.

Variable	N	Mean	Median	SD	Min	Max	Shapiro-Wilk (W)	*p*-value
Citation count	101	17.0	10	22.3	0	123	0.716	< 0.001
Density	101	1.58	1.06	1.65	0.0	8.50	0.807	< 0.001
Publication year	101	2013	2017	13.3	1953	2025	0.714	< 0.001

Spearman's rank correlation coefficients are reported in Table 6. Citation count showed a strong positive correlation with citation density ($\rho = 0.785$, $p < 0.001$), and a strong negative correlation with publication year ($\rho = –0.671$, $p < 0.001$), suggesting that older studies had more time to accumulate citations. A weak but statistically significant positive correlation was observed between journal impact factor and citation count ($\rho = 0.203$, $p = 0.042$). Other associations were not statistically significant.

Table 6- Spearman's rank correlation between bibliometric variables.

Variable Pair	Spearman's ρ	p-value
Citation count × Density	0.785	< 0.001
Citation count x Publication year	–0.671	< 0.001
Citation count × Impact factor	0.203	0.042
Density × Publication year	–0.140	0.163
Density × Impact factor	0.334	< 0.001
Publication year × Impact factor	0.079	0.430

Discussion

Bibliometric reviews are essential tools for providing a comprehensive overview of a research field, allowing for the identification of knowledge gaps and the proposal of new investigative directions.[21] These analyses guide future studies towards more specific and relevant topics within a discipline, thereby contributing to the advancement of scientific knowledge.[22]

The findings of this bibliometric analysis highlight the global distribution of scientific production related to the use of calcium carbonate ($CaCO_3$) in Dentistry, revealing growing interest in this multifunctional and sustainable biomaterial.[23] $CaCO_3$ is a versatile biomaterial, widely available in nature, and known for its biocompatibility, bioactivity, and functionalization potential.[24] Due to its sustainable origin—such as from oyster and mussel shells—it offers environmental value, promoting the integration of clinical innovation, waste reuse, and the redefinition of applicability within the context of green technology advancements.[25-27] Accordingly, numerous scientific studies have investigated the use of calcium carbonate in dental applications. However, to date, no bibliometric reviews specifically addressing this topic have been identified. Thus, the present study aimed to select and evaluate the scientific profile of the most cited articles that address the use of $CaCO_3$ in Dentistry, in order to understand the broader context of this technical advancement and to propose new directions for future developments in the field.

A thorough analysis of the main characteristics of the included articles represents a methodological strength of this bibliometric review, enhancing its quality and credibility.[16] The decision not to impose language or publication year restrictions expanded the scope and representativeness of the sample. Furthermore, the exclusive use of the Web of Science – Core Collection (WoS-CC) database is justified by its recognized comprehensiveness and prestige in the field of bibliometric studies, as validated by previous research in Dentistry.[21,22] Future studies could incorporate multiple databases (e.g., Scopus, Embase) to capture a broader range of studies with diverse geographic and thematic profiles. Although reliance on a single database may be considered a limitation, this strategy ensured methodological consistency and comparability with other studies, thereby strengthening the robustness of the findings.[21]

Citation analysis

The number of citations is often used as a metric to assess the impact and relevance of a study within the scientific community.[16] In certain fields, articles with over 100 citations are considered "classics".[21] In this analysis, only two articles surpassed that threshold—with 123 and 115 citations—while the third, fourth, and fifth ranked articles received 70, 67, and 67 citations, respectively. Compared to other bibliometric analyses in dentistry, this study revealed a relatively low number of self-citations, which enhances the credibility of the results. While self-citation can reflect author productivity, excessive and unjustified practices are negatively viewed for distorting impact metrics.[21]

A weak but positive correlation between journal impact factor and citation count was observed between the impact factor of journals and the number of citations received by the articles (R=0.2; p=0.042), indicating that while journal prestige may influence visibility, other factors—such as novelty, applicability, and thematic relevance—also play crucial roles in scientific impact.[16] Citation density analysis showed that the most recent articles are not necessarily the most cited, suggesting that interest in $CaCO_3$ in Dentistry has been sustained over time, with older publications still being widely referenced.

The most cited article was titled “Physicochemical study of $CaCO_3$ from egg shells,” published by Murakami, et al.[18] (2007), affiliated with the Federal University of Santa Catarina and the University of Joinville Region, in the journal Ciência e Tecnologia de Alimentos. The study demonstrated that calcium carbonate derived from eggshells can be a viable and sustainable alternative for dental applications, exhibiting greater thermal stability and physicochemical properties similar to those of commercial control materials. The high citation count may be attributed to the practical relevance of the topic, the renewable origin of the material, and the increasing interest in environmentally responsible alternatives. Although the article does not delve specifically into dental applications, it was included in this review due to its high citation frequency within the analyzed sample.

In addition to total citations, citation density—defined as the average number of citations per year—was also analyzed to assess the longevity and sustained influence of a study over time. Murakami, et al.[18] also stood out in this regard, exhibiting the highest citation density. The years 2007 and 2013 accounted for the highest citation totals (154 and 146, respectively), emphasizing the importance of publications from this period in consolidating knowledge on $CaCO_3$ in dental contexts.

Year of publication

The timeline of publications reveals a broad historical perspective on the role of calcium carbonate in Dentistry, spanning from the seminal 1953 article by Gore[20] ("The role of calcium carbonate in dental caries") to the cutting-edge 2025 study by Chen, et al.[14] on NIR-responsive nanocomposites for periodontitis therapy. Notably, the most influential studies were published between 1996 (n=56 citations) and 2018 (n=41 citations), collectively accounting for 42.18% of total citations (n=1597). This distribution suggests that while early research laid foundational principles, the late 1990s to late 2010s marked a peak in scientific engagement with $CaCO_3$ applications in dental science. The persistence of this topic over seven decades—from basic caries prevention to advanced biomaterials engineering— underscores its enduring relevance and the evolving research priorities in dental biomaterials. The recent 2025 publication further illustrates ongoing innovation in this field, particularly in therapeutic nanocomposite development.

Contributing journals and impact factor

Among the journals most frequently publishing research on $CaCO_3$ in Dentistry, the American Journal of Dentistry stands out. Established in 1987 and published by the U.S.- based Mosher & Linder, Inc., this journal covers a wide range of topics, including dental therapies, restorative techniques, aesthetics, prevention, and dental materials. Its leadership in the number of articles in this bibliometric review highlights its active role in disseminating advancements related to $CaCO_3$, particularly in the context of new materials and clinical applications.

The second most prominent journal is Caries Research, internationally recognized for its focus on caries prevention, bioactive materials, innovative therapies, and evaluation of dental interventions through both laboratory and clinical studies. The frequency with which these journals appear in this and other bibliometric analyses underscores their relevance to both the scientific and clinical communities, reinforcing their impact in consolidating and disseminating high-quality technical and scientific knowledge in Dentistry.

Study design, research topics, fields of application, and uses of $CaCO_3$

The predominance of laboratory studies among the analyzed articles reflects a

preference for experimental designs that offer greater control over variables and reproducibility. By enabling precise manipulation of experimental conditions, such studies facilitate the identification and evaluation of critical parameters associated with the performance of calcium carbonate-based materials, making their application feasible in various dental contexts. However, the predominance of in vitro studies could also indicate a challenge in translating these findings into clinical settings. The biocompatibility, bioactivity, low toxicity, and versatility of $CaCO_3$ explain the growing interest in this inorganic compound in the formulation of advanced dental products.

Despite its relevance, only three literature reviews were identified in the sample, indicating a significant gap in the field. Systematic and narrative reviews exert substantial influence on clinical practices and research directions, being considered high-level evidence sources. The scarcity of such publications may reflect the early stage of research in this area, with the majority of studies focused on experimental design rather than clinical application. The relative novelty of this field suggests a high potential for consolidation through future reviews, particularly in identifying knowledge gaps in long-term clinical studies and regenerative applications

In terms of application areas, restorative dentistry is the main field for $CaCO_3$ use, particularly in studies focused on $CaCO_3$ used as an abrasive agent in dentifrices, for both mechanical biofilm removal and interactions with resin-based restorations. Additionally, notable contributions were observed in cariology, implantology, periodontology, preventive dentistry, and the development of innovative dental materials. These areas represent the ongoing search for biomaterials capable of addressing both hard and soft tissue challenges in the oral cavity.

This wide range of applications reflects the pursuit of biomaterials that act effectively on both hard and soft oral tissues. Such versatility is particularly valuable in addressing the challenges of oral regeneration. This justifies the growing interest in sustainable technologies, such as obtaining $CaCO_3$ from renewable natural sources or repurposed waste. Despite advances, challenges remain—such as developing structures that mimic the extracellular matrix of dental pulp and promote rapid vascularization—critical factors for cell viability and host cell recruitment, especially in regenerative endodontic strategies.

$CaCO_3$ Source and Forms of Use/Presentation

Analysis of the selected studies revealed the diversity of calcium carbonate sources used in research, with commercial products being the most common (n=55). This prevalence reflects the wide availability and established applicability of standardized market formulations. However, a significant number of studies also utilized naturally derived materials, particularly from eggshells (n=6), mollusk shells (n=2), cuttlefish bone (n=1), equisetum grass (n=1), and Paenibacillus sp. mineral characterization (n=1), indicating growing interest in sustainable alternatives to traditional industrial sources. The presence of $CaCO_3$-based compounds in two publications, alongside synthetic or laboratory-derived materials (n=8), reveals a hybrid landscape between natural and technological solutions, reflecting advances in biomaterials science.

Regarding the forms of presentation and application of $CaCO_3$, dentifrices were markedly predominant, with 31 records, highlighting its established role as an abrasive and/or desensitizing agent in oral hygiene products. Additionally, bone grafts or substitutes (n=6) and desensitizing pastes (n=8) reinforce the role of $CaCO_3$ in regenerative and therapeutic contexts. Other applications include abrasive materials (n=5), scaffolds, pulp capping agents, nanoparticles, and biomaterials. This diversity of approaches demonstrates the versatility of $CaCO_3$ as a functional platform in various forms and clinical settings. The growing interest in $CaCO_3$-based composites, bioceramics, nanofibers, and hydrogels reflects a trend towards more sustainable, bioactive, and minimally invasive solutions in contemporary dentistry.

Global Landscape

In terms of geographical distribution, the United States leads in both the number of publications (n=13) and total citations (n=221), reflecting its consolidated position as a global hub of research and technological innovation. China ranks second in both publications (n=9) and citations (n=111), which can be attributed to its increasing investment in science and technology, the strengthening of its universities, and incentives for the internationalization of scientific output. Brazil also contributes significantly to this field, with a strong showing in both publications and citations. These countries host centers of excellence, robust infrastructure, and well-established collaborative networks, all of which contribute to high scientific productivity and international visibility.

Among the ten most cited articles in the analyzed sample, two were authored by Brazilian researchers — including the top-ranked publication — while the United States ranks second. This result reflects not only the quality and impact of Brazilian studies in the field but also their growing relevance in the global discourse on sustainable biomaterials. The contribution of Brazilian research highlights emerging strengths in sustainable innovations, particularly the use of $CaCO_3$ derived from renewable sources.

Contributing institutions

The institutional contribution analysis revealed a globally distributed research effort, with 145 institutions publishing on $CaCO_3$ applications in dentistry. As presented in Table 3, the most productive institutions were led by the State University of Campinas (4 articles), followed by Colgate-Palmolive Company, Egyptian Knowledge Bank, Loma Linda University, and Wuhan University (3 articles each). Notably, the tiebreaker of cumulative Web of Science citations highlights the competitive research output among these leading institutions. The prominence of academic institutions alongside industry players (Colgate-Palmolive) reflects the translational nature of $CaCO_3$ research, bridging fundamental science and commercial applications in dental care. This global institutional diversity reflects the broad interest and the growing collaborations between academia and industry. This distribution suggests both broad international interest and concentrated expertise hubs driving innovation in calcium carbonate applications, from biomaterials to preventive dentistry formulations. The presence of multiple institutions with equivalent publication numbers (3 articles) underscores the balanced global contribution to this field, while citation metrics reveal variations in research impact among these productive centers.

Keywords

Regarding the most prevalent keywords, the identification of “calcium carbonate” and “hydroxyapatite” as core terms was expected, given their widespread use in dental biomaterials research. These compounds are frequently explored for their biocompatibility and potential in regenerative applications. The co-occurrence of clinically oriented terms such as “in-vitro”, “fluoride”, “toothpaste”, and “enamel” underscores the translational focus of these studies, particularly in preventive and

restorative dentistry. The presence of “pH changes” and “dentifrice” further emphasizes the role of these materials in modulating the oral environment and maintaining homeostasis. The use of VOSviewer to create visual maps of keyword co-occurrence reflects its utility in exploring thematic structures and research trends in the field.

Contributing authors

The bibliometric analysis revealed a collaborative research landscape involving 472 authors, with distinct patterns in productivity and impact. DeVizio W emerged as the most prolific contributor (4 articles), followed by Mateo LR and Zhang YP (3 articles each), all affiliated with Colgate-Palmolive Company. Their clinical studies primarily investigated $CaCO_3$ in dentifrices, focusing on caries prevention, extrinsic stain removal, and gingivitis management. While one study reported no significant improvement in supragingival calculus or gingivitis reduction, the others highlighted $CaCO_3$’s efficacy in stain removal and its potential role in caries prevention, underscoring its dual utility in aesthetic and preventive dentistry.

Notably, the most cited authors were Piatelli A and Scarano A (129 citations each), whose clinical research demonstrated $CaCO_3$’s success as a bone substitute in pre-implant procedures and maxillary sinus augmentation, emphasizing its osteogenic potential. This dichotomy in research focus—between therapeutic applications (bone regeneration) and preventive/aesthetic uses (dentifrices)—reflects the mineral’s versatility in dental science. The collaboration network (Figure 6) and ranking of top contributors (Table 4) further reveal how institutional expertise (e.g., Colgate-Palmolive) and clinical research groups drive distinct yet complementary advancements. Together, these findings illustrate $CaCO_3$’s broad applicability, from foundational biomaterial science to translational clinical outcomes, while highlighting gaps, such as inconsistent gingivitis results, that warrant further investigation

Limitations and Future Directions

To contextualize these findings, it is important to acknowledge several limitations. First, the analysis was restricted to a single database (Web of Science Core Collection), which may limit the generalizability of the results. The inclusion of additional databases—such as Scopus, Embase, or regional sources—could capture studies with different thematic or geographic profiles. Second, although relevant

associations were identified using Spearman's rank correlation, the study did not employ multivariate regression models that could provide deeper insights into the factors influencing citation impact. Third, although blinded and independent screening was applied, the process is still subject to interpretation bias. Despite the high inter-rater agreement, clearer reporting on reviewer calibration could strengthen the reliability of future studies. Another limitation is the exclusion of studies where $CaCO_3$ was present in the formulation but not explicitly mentioned in the title, abstract, or keywords—potentially omitting relevant clinical trials, especially those involving dentifrices and desensitizing products. Future bibliometric reviews should adopt broader search strategies, including full-text screening, to better reflect the clinical and commercial relevance of $CaCO_3$ in dentistry.

In addition, future research should address gaps such as the limited number of long- term clinical studies, systematic reviews, and investigations focused on regenerative applications. The growing interest in sustainability also points to the need for further studies on biogenic and waste-derived sources of $CaCO_3$. Expanding keyword structures, using multiple databases, analyzing funding sources, and examining citation contexts are recommended strategies to enhance the scope and impact of future bibliometric analyses in this field.

Conclusions

In conclusion, this bibliometric analysis highlights a growing interest in the application of calcium carbonate in dentistry, with a progressive increase in scientific output over the years. The findings underscore the global distribution of research and emphasize the relevance of this biomaterial in various dental specialties. This study reinforces several key points for research groups worldwide engaged in the development of innovative dental materials, providing valuable direction for future investigations, which remain limited in scope, especially regarding clinical applications and long-term outcomes, and the integration of bibliometric variables such as study design, author networks, and funding sources. Future research would benefit from the inclusion of multiple bibliographic databases, the application of advanced techniques (e.g., altmetrics, citation trajectory analysis), and the expansion of variable sets to support a more comprehensive understanding of knowledge dynamics in this field.

Conflict of interest

The authors declare no conflict of interest.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding

This research was supported by Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina (FAPESC) and the National Council for Scientific and Technological Development (CNPq) under the following grants: EDITAL DE CHAMADA PÚBLICA FAPESC/CNPq Nº 38/2022 – Programa de Apoio à Pesquisa Aplicada para Fixação de Jovens Doutores em Santa Catarina (Grant No. 2023TR000248), and EDITAL DE CHAMADA PÚBLICA FAPESC Nº 21/2024 – Programa de Pesquisa Universal (Grant No. 2024TR002663).

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Figure Legends

Figure 1- Flowchart of the search and eligibility process.

Figure 2- Top 10 most-cited articles on $CaCO_3$ in dentistry based on Web of Science – Core Collection (WoS-CC).

Figure 3- Distribution of the number of publications over the years.

Figure 4- Global distribution of the origin of publications on CaCO3 in dentistry.

Figure 5- Density map of the main keywords associated with the study. A minimum of 4 occurrences was required for inclusion. Larger nodes and bold labels represent keywords with stronger co-occurrence links.

Figure 6- Density map of authors and their collaborative co-authorship networks.

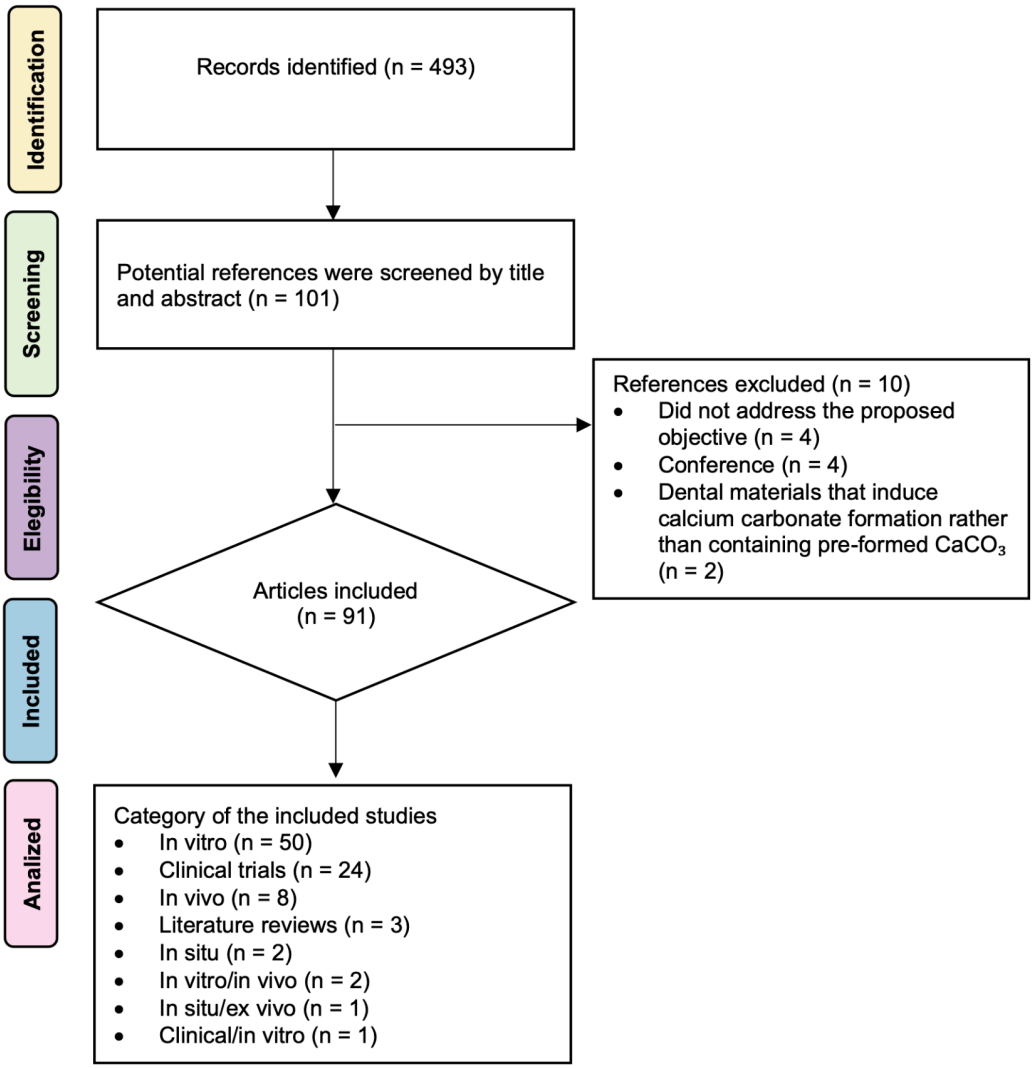

Figure 1- Flowchart of the search and eligibility process

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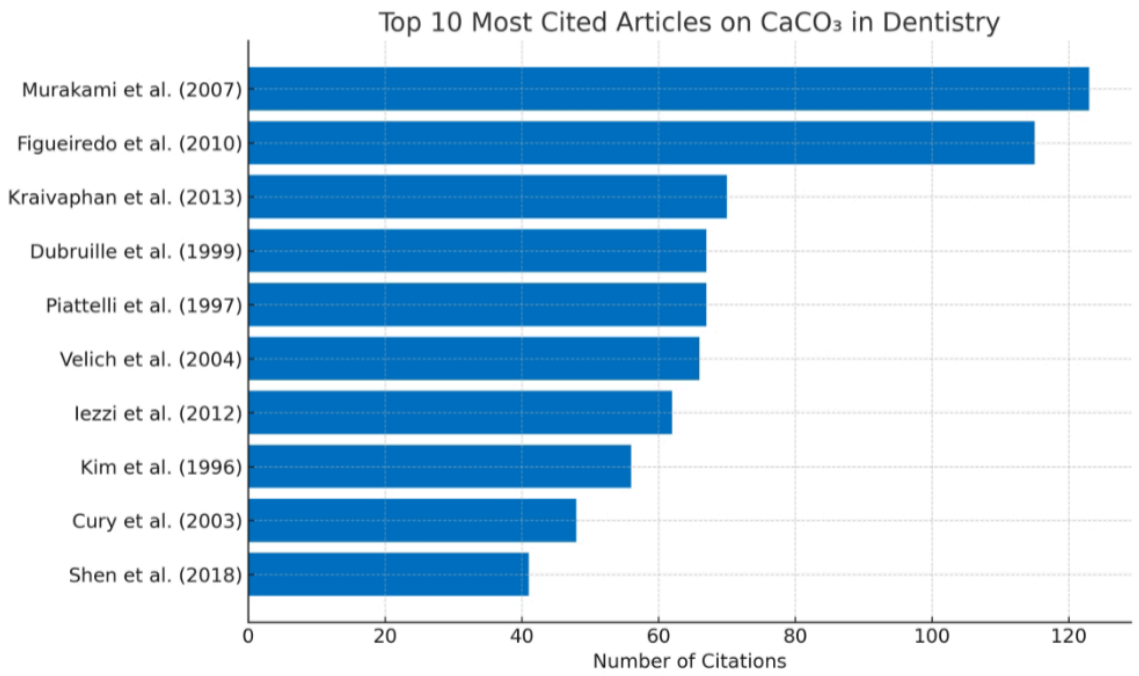

Figure 2- Top 10 most-cited articles on $CaCO_3$ in dentistry based on Web of Science – Core Collection (WoS-CC).

254x152mm (300 x 300 DPI)

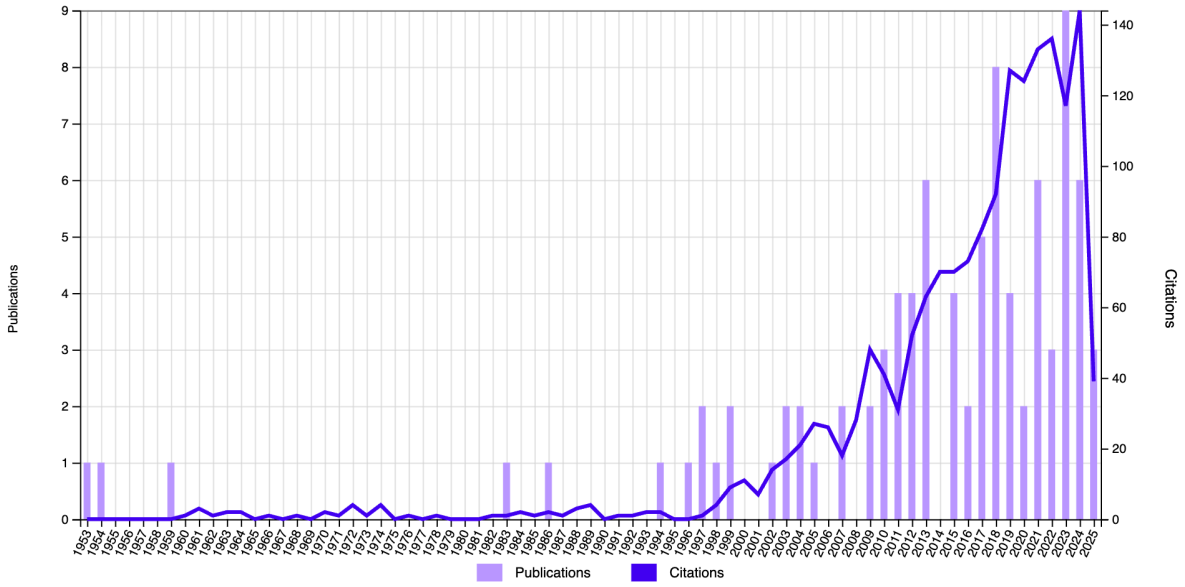

Figure 3- Distribution of the number of publications over the years.

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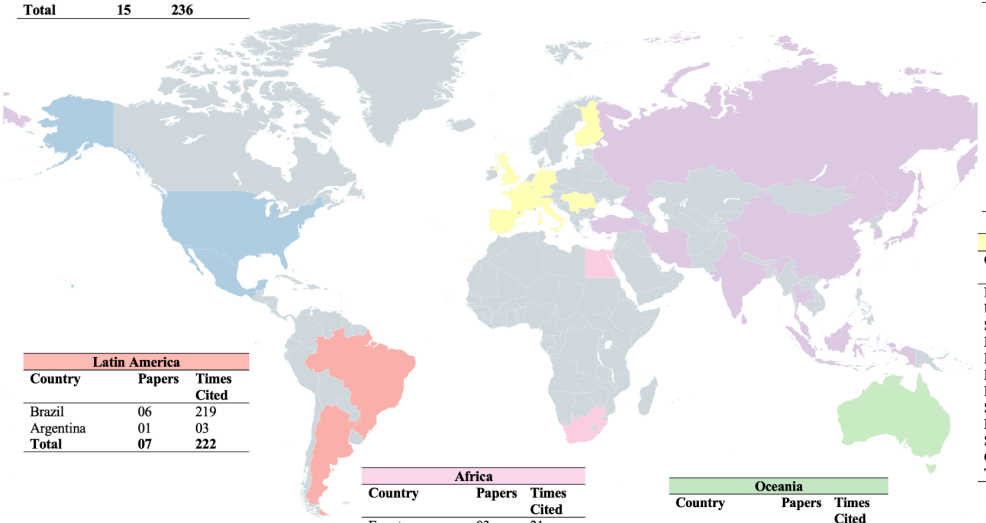

Anglo-Saxon America		
Country	**Papers**	**Times Cited**
USA	13	221
Mexico	02	15
Total	**15**	**236**

Asia		
Country	**Papers**	**Times Cited**
China	09	111
India	07	34
Japan	06	73
Thailand	03	30
Qatar	03	14
Iran	03	07
Indonesia	02	29
Russia	02	20
Taiwan	02	05
Turkey	01	31
South Korea	01	56
Malaysia	01	30
Total	**40**	**440**

Europe		
Country	**Papers**	**Times Cited**
Italy	06	173
United Kingdom	05	119
Serbia	02	16
Romania	02	00
Portugal	01	115
France	01	67
Hungary	01	66
Switzerland	01	13
Finland	01	04
Spain	01	03
Germany	01	00
Total	**22**	**576**

Latin America		
Country	**Papers**	**Times Cited**
Brazil	06	219
Argentina	01	03
Total	**07**	**222**

Africa		
Country	**Papers**	**Times Cited**
Egypt	03	21
South Africa	01	23
Total	**04**	**44**

Oceania		
Country	**Papers**	**Times Cited**
Australia	03	79
Total	**03**	**79**

Figure 4- Worldwide distribution of the origin of Figure 4- Global distribution of the origin of publications on CaCO3 in dentistry.

1411x793mm (72 x 72 DPI)

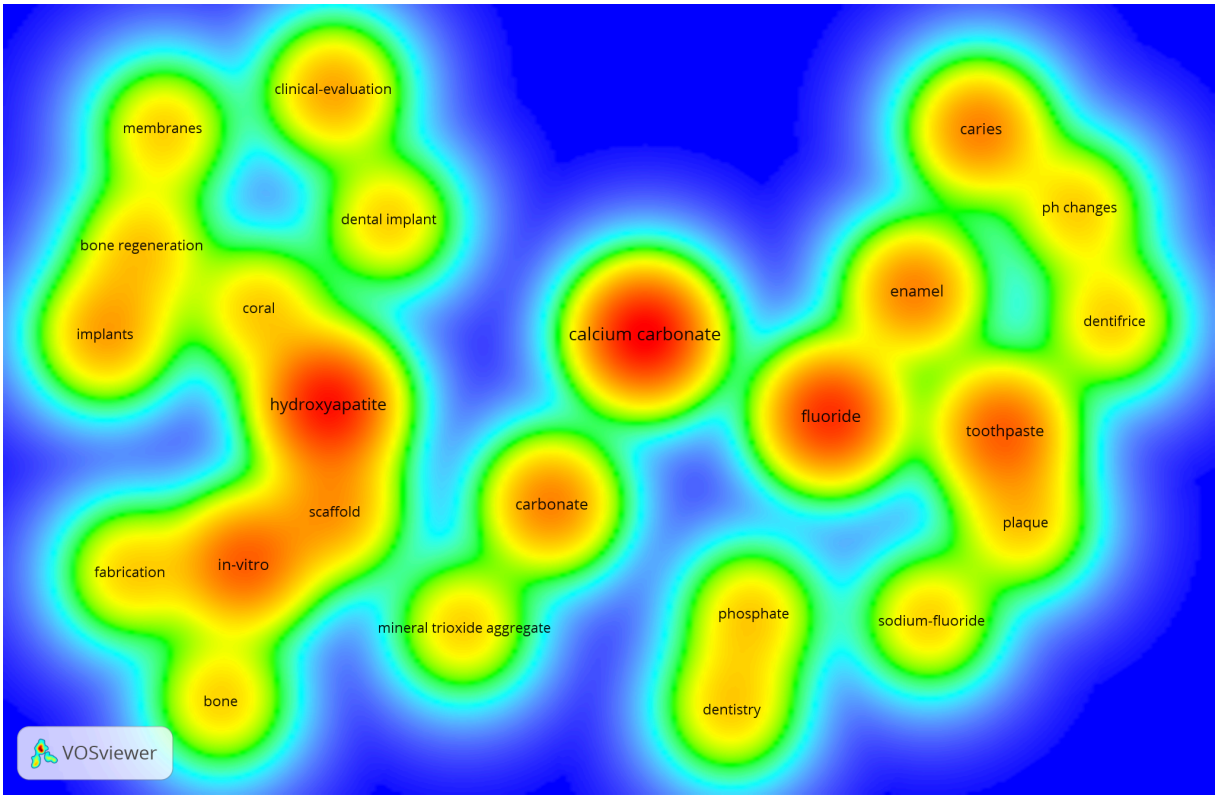

Figure 5- Density map of the main keywords associated with the study. A minimum of 4 occurrences was required for inclusion. Larger nodes and bold labels represent keywords with stronger co-occurrence links.

51917x33934mm (1 x 1 DPI)

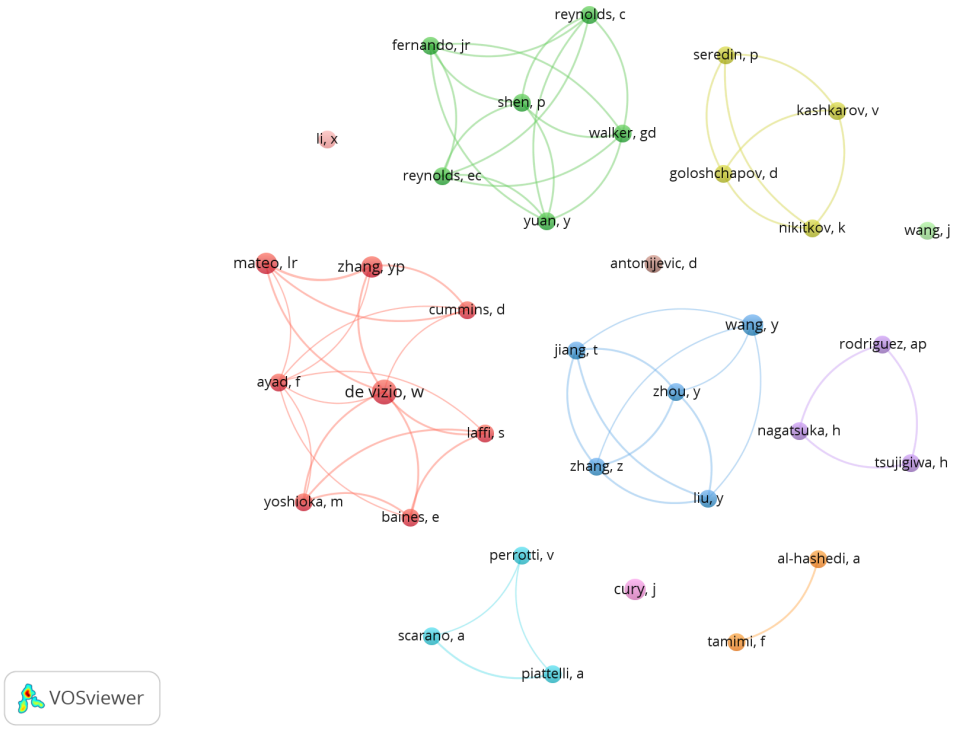

Figure 6- Density map of authors and their collaborative co-authorship networks.

51917x33934mm (1 x 1 DPI)

Tables

Supplementary Table

Table 1- Search strategy for $CaCO_3$ in dental applications on Web of Science (WoS)

Search Strategy	Keywords
Calcium Carbonate Variants	"calcium carbonate" OR "CaCO3" OR "limestone" OR "aragonite" OR "calcite" OR "vaterite"
Dental Applications	"dental applications" OR "dentistry" OR "dental materials" OR "dental" OR "dental therapy" OR "dental restorations" OR "dental sealers" OR "dental implants" OR "endodontics" OR "periodontics" OR "orthodontics" OR "enamel repair" OR "dentin regeneration" OR "tooth remineralization" OR "dental caries" OR "tooth repair" OR "stomatology" OR "dental radiology" OR "pediatric dentistry" OR "dental care for children" OR "preventive dentistry" OR "dental sealants" OR "dental, oral and maxillofacial"
Combined Query	TS=("calcium carbonate" OR "CaCO3" OR "limestone" OR "aragonite" OR "calcite" OR "vaterite") AND TS=("dental applications" OR "dentistry" OR "dental materials" OR "dental" OR "dental therapy" OR "dental restorations" OR "dental sealers" OR "dental implants" OR "endodontics" OR "periodontics" OR "orthodontics" OR "enamel repair" OR "dentin regeneration" OR "tooth remineralization" OR "dental caries" OR "tooth repair" OR "stomatology" OR "dental radiology" OR "pediatric dentistry" OR "dental care for children" OR "preventive dentistry" OR "dental sealants" OR "dental, oral and maxillofacial")

Table 2- Journals that published the most on CaCO3 in dentistry.

Source title	Number of papers	Impact factor
American Journal of Dentistry	08	0.9
Caries Research	06	2.9
BMC Oral Health	04	2.6
Journal of Periodontology	03	4.2
Dental Materials Journal	03	1.9
Materials Science & Engineering C – Materials for Biological Applications	02	8.1
Ceramics International	02	5.1
Nanomaterials	02	4.4
Journal of Biomedical Materials Research Part B – Applied	02	3.2
International Dental Journal	02	3.2

Table 3- Institutions with more publications on CaCO3 in dentistry.

Institutions	Number of articles	Number of citations
State University of Campinas	4	78
Loma Linda University	3	97
Wuhan University	3	67
Egyptian Knowledge Bank (EKB)	3	21
Colgate-Palmolive Company	3	14
University of Melbourne	2	56
Unilever	2	53
Kasetsart University	2	29
Voronezh State University	2	20
University of Belgrade	2	16

Table 4- Authors with more publications on CaCO3 in dentistry.

Authors	Number of papers	Number of citations
DeVizio W	4	104
Mateo LR	3	77
Zhang YP	3	77
Cummins D	2	73
Cury JA	2	64
Fernando JR	2	56
Jiang, T	2	56
Baines E	2	30
Goloshchapov, D	2	20
Kashkarov, V	2	20

Table 5- Descriptive statistics of bibliometric variables.

Variable	N	Mean	Median	SD	Min	Max	Shapiro-Wilk (W)	*p*-value
Citation count	101	17.0	10	22.3	0	123	0.716	< 0.001
Density	101	1.58	1.06	1.65	0.0	8.50	0.807	< 0.001
Publication year	101	2013	2017	13.3	1953	2025	0.714	< 0.001

Table 6- Spearman's rank correlation between bibliometric variables.

Variable Pair	Spearman's ρ	p-value
Citation count × Density	0.785	< 0.001
Citation count x Publication year	–0.671	< 0.001
Citation count × Impact factor	0.203	0.042
Density × Publication year	–0.140	0.163
Density × Impact factor	0.334	< 0.001
Publication year × Impact factor	0.079	0.430

Supplementary Table

Supplementary Table 1- Most-cited global articles on calcium carbonate ($CaCO_3$) in dentistry, ranked by Web of Science Core Collection (WoS-CC) citations.

Position	Papers	Number of citations (Citation density) WoS-CC
1	Murakami FS, Rodrigues PO, de Campos CMT, Silva MAS. Physicochemical study of CaCO3 from egg shells. Cienc Tecnol Aliment. 2007 Jul-Sep;27(3):658-662. doi: 10.1590/S0101-20612007000300035.	123
2	Figueiredo M, Henriques J, Martins G, Guerra F, Judas F, Figueiredo H. Physicochemical Characterization of Biomaterials Commonly Used in Dentistry as Bone Substitutes-Comparison with Human Bone. J Biomed Mater Res B Appl Biomater. 2010 Feb;92B(2):409-419. doi: 10.1002/jbm.b.31529.	115
3	Kraivaphan P, Amornchat C, Triratana T, Mateo LR, Ellwood R, Cummins D, DeVizio W, Zhang YP. Two-Year Caries Clinical Study of the Efficacy of Novel Dentifrices Containing 1.5% Arginine, an Insoluble Calcium Compound and 1,450 ppm Fluoride. Caries Res. 2013;47(6):582-590. doi: 10.1159/000353183.	70
4	Dubruille JH, Viguier E, Le Naour G, Dubruille MT, Auriol M, Le Charpentier Y. Evaluation of combinations of titanium, zirconia, and alumina implants with 2 bone fillers in the dog. Int J Oral Maxillofac Implants. 1999 Mar-Apr;14(2):271-277. PMID: 10212545.	67
5	Piattelli A, Podda G, Scarano A. Clinical and histological results in alveolar ridge enlargement using coralline calcium carbonate. Biomaterials. 1997 Apr;18(8):623-627. doi: 10.1016/S0142-9612(96)00158-5. PMID: 9134162.	67
6	Velich N, Németh Z, Tóth C, Szabó G. Long-term results with different bone substitutes used for sinus floor elevation. J Craniofac Surg. 2004 Jan;15(1):38-41. doi: 10.1097/00001665-200401000-00013. PMID: 14704560.	66
7	Iezzi G, Degidi M, Piattelli A, Mangano C, Scarano A, Shibli JA, Perrotti V. Comparative histological results of different biomaterials	62

	used in sinus augmentation procedures: a human study at 6 months. Clin Oral Implants Res. 2012 Dec;23(12):1369-1376. doi: 10.1111/j.1600-0501.2011.02308.x. PMID: 22092377.	
8	Kim CK, Choi EJ, Cho KS, Chai JK, Wikesjo UME. Periodontal repair in intrabony defects treated with a calcium carbonate implant and guided tissue regeneration. J Periodontol. 1996 Dec;67(12):1301-1306. doi: 10.1902/jop.1996.67.12.1301. PMID: 8997677.	56
9	Cury JA, Francisco SB, Simoes GS, Cury AAD, Tabchoury CPM. Effect of a calcium carbonate-based dentifrice on enamel demineralization in situ. Caries Res. 2003 May-Jun;37(3):194-199. doi: 10.1159/000070444. PMID: 12740543.	48
10	Shen P, Walker GD, Yuan Y, Reynolds C, Stanton DP, Fernando JR, Reynolds EC. Importance of bioavailable calcium in fluoride dentifrices for enamel remineralization. J Dent. 2018 Nov;78:59-64. doi: 10.1016/j.jdent.2018.08.005. PMID: 30099066.	41
11	Mainwaring PJ, Naylor MN. A 4-year clinical study to determine the caries-inhibiting effect of calcium glycerophosphate and sodium-fluoride in calcium-carbonate base dentifrices containing sodium monofluorophosphate. Caries Res. 1983;17(3):267-276. doi: 10.1159/000260677. PMID: 6342787.	38
12	Suzuki T, Kyoizumi H, Finger WJ, Kanehira M, Endo T, Utterodt A, Hisamitsu H, Komatsu M. Resistance of nanofill and nanohybrid resin composites to toothbrush abrasion with calcium carbonate slurry. Dent Mater J. 2009 Nov;28(6):708-716. doi: 10.4012/dmj.28.708. PMID: 20019422.	37
13	Wikesjo UME, Lim WH, Razi SS, Sigurdsson TJ, Lee MB, Tatakis DN, Hardwick WR. Periodontal repair in dogs: A bioabsorbable calcium carbonate coral implant enhances space provision for alveolar bone regeneration in conjunction with guided tissue regeneration. J Periodontol. 2003 Jul;74(7):957-964. doi: 10.1902/jop.2003.74.7.957. PMID: 12931757.	37
14	Lynch RJM, ten Cate JM. The anti-caries efficacy of calcium carbonate-based fluoride toothpastes. Int Dent J.	36

	2005;55(3):175-178. doi: 10.1111/j.1875-595x.2005.tb00057.x. PMID: 16004249.	
15	Liu Y, Jiang T, Zhou Y, Zhang Z, Wang Z, Tong H, Shen X, Wang Y. Evaluation of the attachment, proliferation, and differentiation of osteoblast on a calcium carbonate coating on titanium surface. Mater Sci Eng C Mater Biol Appl. 2011 Jul 20;31(5):1055-1061. doi: 10.1016/j.msec.2011.03.003.	34
16	Tas AC. Porous, biphasic CaCO3-calcium phosphate biomedical cement scaffolds from calcite (CaCO3) powder. Int J Appl Ceram Technol. 2007;4(2):152-163. doi: 10.1111/j.1744-7402.2007.02122.x.	31
17	AbdulQader ST, Ab Rahman I, Ismail H, Kannan TP, Mahmood Z. A simple pathway in preparation of controlled porosity of biphasic calcium phosphate scaffold for dentin regeneration. Ceram Int. 2013 Apr;39(3):2375-2381. doi: 10.1016/j.ceramint.2012.08.089.	30
18	Ana ID, Satria GAP, Dewi AH, Ardhani R. Bioceramics for Clinical Application in Regenerative Dentistry. Adv Exp Med Biol. 2018;1077:309-316. doi: 10.1007/978-981-13-0947-2_16. PMID: 30357695.	29
19	Wang Y, Mei L, Gong L, Li J, He S, Ji Y, Sun W. Remineralization of early enamel caries lesions using different bioactive elements containing toothpastes: An in vitro study. Technol Health Care. 2016;24(5):701-711. doi: 10.3233/THC-161221. PMID: 27233091.	29
20	Chaysuwan D, Sirinukunwattana K, Kanchanatawewat K, Heness G, Yamashita K. Machinable glass-ceramics forming as a restorative dental material. Dent Mater J. 2011 May;30(3):358-367. doi: 10.4012/dmj.2010-154. PMID: 21597218.	28
21	Goloshchapov DL, Lenshin AS, Savchenko DV, Seredin PV. Importance of defect nanocrystalline calcium hydroxyapatite characteristics for developing the dental biomimetic composites. Results Phys. 2017;7:3853-3860. doi: 10.1016/j.rinp.2017.09.055.	24
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4 CONSIDERAÇÕES FINAIS

A análise dos 91 artigos selecionados sobre a aplicação de carbonato de cálcio em biomateriais odontológicos evidenciou tendências relevantes na produção científica internacional. O estudo "*Physicochemical study of $CaCO_3$ from egg shells"* de autoria de Murakami *et a*l. (2007), destacou-se como o mais citado, refletindo o interesse crescente na utilização de fontes alternativas e sustentáveis de CaCo3.

Em relação ao delineamento metodológico, observou-se predominância de estudos *in vitro*, indicando o foco inicial na avaliação das propriedades físico-químicas e biológicas do material antes da sua aplicação clínica. Em seguida, aparecem os estudos clínicos, que demonstram um esforço para que ocorra o avanço translacional das pesquisas e o potencial real da aplicação do carbonato de cálcio nos produtos odontológicos.

O intervalo temporal dos artigos mais citados, compreendido entre 1996 e 2018, revela uma trajetória de amadurecimento científico, no qual os estudos pioneiros abriram espaço para abordagens mais sofisticadas envolvendo nanotecnologia e biomineralização. Geograficamente, os Estados Unidos da América lideraram em número de publicações, refletindo a forte tradição em pesquisa aplicada, principalmente estudos *in vitro*. Entretanto, a Ásia emergiu como o continente com maior produção científica com estudos descentralizados por todo o continente, indicando expansão global do interesse pelo tema e o fortalecimento de centros de pesquisa, como China, Índia e Japão. O autor DeVizio W., foi notavelmente o pesquisador com maior volume de publicações, sinalizando sua influência no avanço do conhecimento sobre o uso de compostos a base de carbonato de cálcio, principalmente no desenvolvimento de pastas dessensibilizadores.

A Universidade Estadual de Campinas (UNICAMP) sobressai-se com a maior contribuição de artigos, demonstrando o potencial de pesquisa brasileiro. Observou-se também, um número equilibrado de três publicações cada, provenientes de outras universidades, mas também de instituições internacionais focadas no desenvolvimento de produtos comerciais, como a *Colgate-Palmolive Company*. A análise das palavras-chave mais recorrentes revelou o predomínio de termos como "*calcium carbonate*" e "*hydroxyapatite*", refletindo o foco das pesquisas na caracterização e no uso de compostos minerais com propriedades

remineralizantes. Além disso, a co-ocorrência de palavras-chave frequentemente associadas, como “*membrane*”, “*bone regeneration*” e “*implants*”, evidencia a relação entre o uso do carbonato de cálcio e o desenvolvimento de biomateriais aplicados à implantodontia.

Quanto aos periódicos, o *American Journal of Dentistry* destacou-se como o principal veículo de publicação, seguido pela revista *Caries Research*. As áreas temáticas mais frequentes foram dentística restauradora e cariologia, sendo essa última também a principal aplicação identificada, especialmente em estudos voltados à prevenção e remineralização de lesões cariosas. Em seguida observou-se um expressivo número de pesquisas relacionadas ao controle da hipersensibilidade dentinária, evidenciando o interesse no potencial do carbonato de cálcio como agente funcional, capaz de promover a oclusão dos túbulos dentinários e proporcionar maior conforto dental aos pacientes.

Em relação à origem do carbonato de cálcio, observou-se que a maioria dos estudos utilizou o material proveniente de marcas comerciais, frequentemente incorporado em pesquisas com dentifrícios. Entretanto, nota-se um número considerável de trabalhos nos quais a obtenção do $CaCO_3$ ocorreu a partir de fontes alternativas e sustentáveis, como conchas de moluscos, cascas de ovos e outro resíduos da maricultura, além de fontes vegetais como a cavalinha (*Equisetum)*.

Essa tendência reflete uma nítida mudança de paradigma em direção à valorização de resíduos biogênicos e à redução dos impactos ambientais associados à mineração tradicional. Estando alinhada com os Objetivos do Desenvolvimento Sustentável (ODS) da Agenda 2030 da ONU, ao valorizar esses resíduos, essas iniciativas promovem o ODS 9 (Indústria, Inovação e Infraestrutura), incentivando a adoção de rotas produtivas limpas e tecnologias inovadoras, como os biomateriais; ODS 12 (Consumo e Produção Responsáveis), ao promover a economia circular que transforma subprodutos em recursos valiosos; e o ODS 13 (Ação Contra a Mudança Global do Clima), através da transformação do material, pode-se diminuir a pegada de carbono da cadeia produtiva, uma vez que se torna uma alternativa à mineração do mineral. Além disso, o reaproveitamento dos resíduos marinhos contribui para o ODS 14 (Vida na Água) e ODS 15 (Vida Terrestre), fortalecendo o compromisso da ciência e da odontologia com práticas ambientalmente conscientes e socialmente responsáveis.

A transição gradual para fontes alternativas e renováveis de carbonato de cálcio é uma estratégia inteligente ao atenuar os impactos ambientais causados pela mineração tradicional e, futuramente, consolidar um caminho estratégico para uma odontologia cientificamente avançada e ecologicamente responsável. Os resultados desta pesquisa sugerem uma forte tendência de pesquisa experimental e clínica promissora, focada na aplicação do carbonato de cálcio em dentifrícios para a prevenção da cárie e o manejo da hipersensibilidade dentinária. Dessa forma, o futuro aponta para a integração dos benefícios clínicos do carbonato de cálcio a um ciclo de produção pautado em princípios de responsabilidade ambiental e social.

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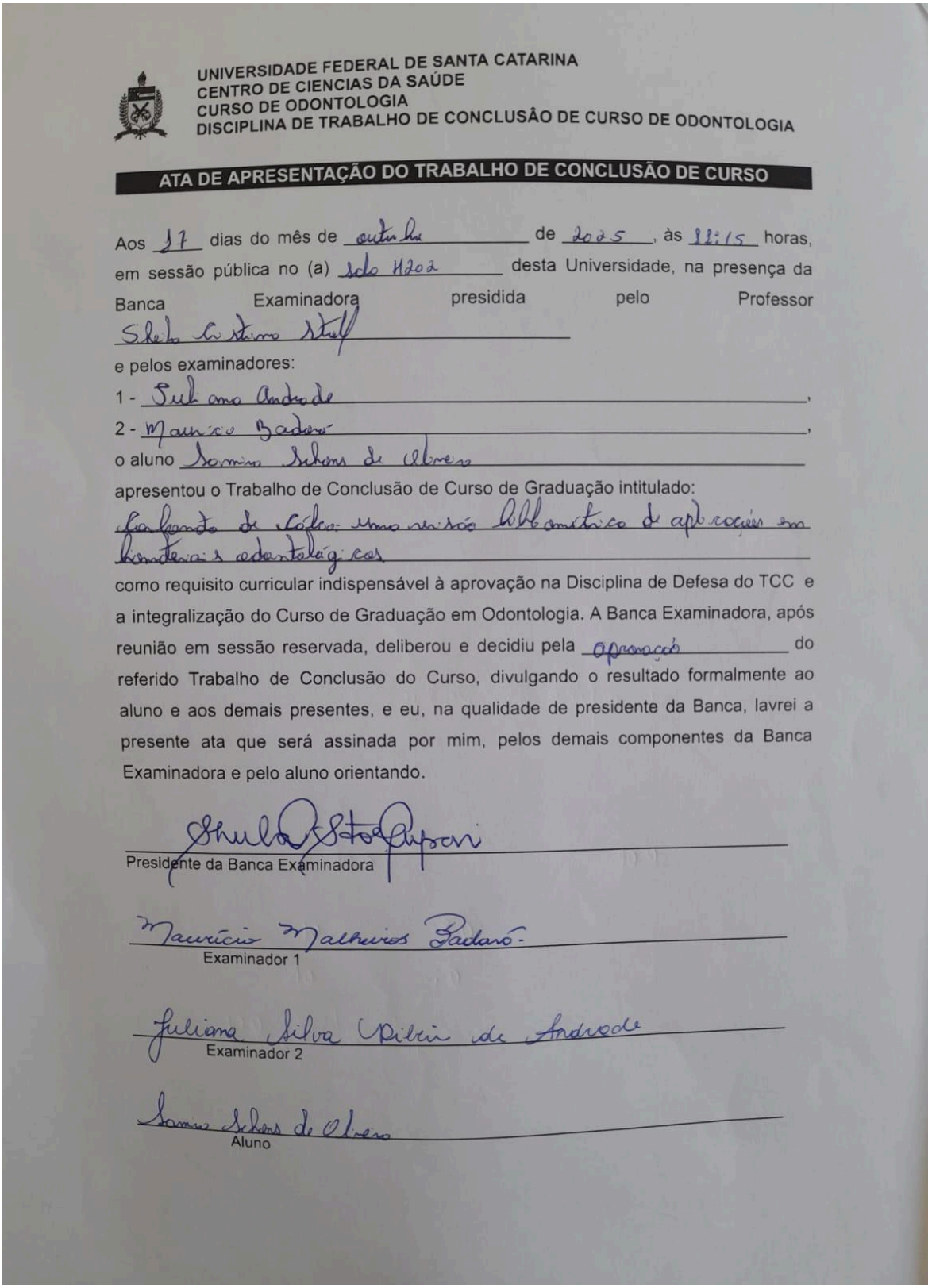
ANEXO 1 - ATA DA DEFESA



UNIVERSIDADE FEDERAL DE SANTA CATARINA
CENTRO DE CIENCIAS DA SAÚDE
CURSO DE ODONTOLOGIA
DISCIPLINA DE TRABALHO DE CONCLUSÂO DE CURSO DE ODONTOLOGIA

ATA DE APRESENTAÇÃO DO TRABALHO DE CONCLUSÃO DE CURSO

Aos 17 dias do mês de outubro de 2025, às 11:15 horas, em sessão pública no (a) sala H202 desta Universidade, na presença da Banca Examinadora presidida pelo Professor Sheila Cristina Stolf
e pelos examinadores:
1 - Juliana Andrade,
2 - Mauricio Badaró,
o aluno Samira Soares de Oliveira
apresentou o Trabalho de Conclusão de Curso de Graduação intitulado:
Conforto de cólon: uma revisão bibliométrica de aplicações em biomateriais odontológicos
como requisito curricular indispensável à aprovação na Disciplina de Defesa do TCC e a integralização do Curso de Graduação em Odontologia. A Banca Examinadora, após reunião em sessão reservada, deliberou e decidiu pela aprovação do referido Trabalho de Conclusão do Curso, divulgando o resultado formalmente ao aluno e aos demais presentes, e eu, na qualidade de presidente da Banca, lavrei a presente ata que será assinada por mim, pelos demais componentes da Banca Examinadora e pelo aluno orientando.

Presidente da Banca Examinadora

Mauricio Malheiros Badaró
Examinador 1

Juliana Silva Pitrin de Andrade
Examinador 2

Samira Soares de Oliveira
Aluno

ANEXO 2 - NORMAS DA REVISTA

Formato de Envio dos Artigos

Title page

Deverá ser submetida em arquivo separado do arquivo principal e conter:

a) O título do manuscrito em inglês.

b) Os nomes dos autores na ordem direta seguido da sua afiliação institucional. Para autores brasileiros, as afiliações devem vir em português, em espanhol para latino-americanos e em inglês para as demais nacionalidades.

A autoria deverá ser atribuída seguindo as recomendações do ICMJE: contribuições substanciais à concepção ou projeto do estudo; ou coleta, análise, ou interpretação dos dados do estudo; redação ou revisão crítica com importante contribuição intelectual; aprovação final da versão a ser publicada; e concordância de se responsabilizar por todos os aspectos do trabalho, assegurando que as questões relacionadas com a exatidão e integridade de qualquer parte do estudo foram devidamente investigadas e resolvidas.

Todos os autores devem ter registro no ORCID (https://orcid.org/) e vinculá-lo ao registro no ScholarOne. Consulte o Guia do Autor para orientações de como vincular o ORCID a sua conta no ScholarOne.

Todos os autores deverão ser adicionados na etapa 4 do processo de submissão no sistema ScholarOne.

Todos os autores devem descrever a sua participação na elaboração do manuscrito, usando a estrutura de taxonomia do CREDiT, contidas no Formulário de Submissão e também durante a submissão do manuscrito no ScholarOne.

c) Endereço completo do autor correspondente, a quem todas as correspondências serão endereçadas, incluindo telefone e endereço de e-mail.

d) Informação sobre o depósito do manuscrito em um servidor de preprints, quando for o caso, indicando o endereço de acesso e número DOI; citação e referenciamento dos dados de pesquisa especificando o repositório e o número DOI. Anexar o formulário de Conformidade com a Ciência Aberta.

e) Nota obrigatória informando se o manuscrito é derivado de dissertações ou teses e seu respectivo endereço de acesso quando disponível.

Arquivo principal

O manuscrito deverá ser previamente traduzido ou revisado quanto à língua inglesa por empresa, profissional autônomo ou autores que tenham a língua inglesa como nativa.

a) Título do trabalho em inglês.

b) Resumo estruturado de no máximo 300 palavras em parágrafo único, contendo as seguintes subseções: breve introdução, objetivo, metodologia, resultados e conclusões.

c) Palavras-chave: correspondem às palavras ou expressões que identificam o conteúdo do artigo. Para determinação das palavras-chave, os autores deverão consultar a lista de assuntos do MeSH e DeCS. Deve-se adicionar de 3 a 5 palavras-chave separadas entre si por pontos e devem ter a primeira letra da primeira palavra em letra maiúscula. Ex: Dental implants. Fixed prosthesis. Photoelasticity. Passive fit.

d) Introdução: resumo do raciocínio e a proposta do estudo, citando somente referências pertinentes. Estabelecer a hipótese do trabalho.

e) Metodologia: o material e os métodos são apresentados com detalhes suficientes para permitir a confirmação das observações. Incluir cidade, estado e país de todos os fabricantes depois da primeira menção dos produtos, instrumentais, softwares,

equipamentos, etc. Métodos publicados devem ser referenciados e discutidos brevemente, exceto se modificações tenham sido feitas. Indicar os métodos estatísticos utilizados, se aplicável. Consultar o item princípios éticos e registro de ensaios clínicos.

f) Resultados: devem ser apresentados em uma sequência lógica no texto, com tabelas e ilustrações. Não repetir no texto todos os dados das tabelas e ilustrações, enfatizando somente as observações importantes.

g) Discussão: enfatizar os aspectos novos e importantes do estudo contextualizando com observações de investigações prévias. Não repetir em detalhes dados ou informações citadas na introdução ou resultados. Apontar as implicações de seus achados e suas limitações.

h) Conclusão: Listar sucintamente as conclusões que podem ser extraídas da pesquisa. Não apenas reafirmar os resultados, mas estabelecer conclusões pertinentes aos objetivos e justificadas pelos dados. Na maioria das situações, as conclusões são verdadeiras apenas para a população do experimento.

i) Agradecimentos (quando apropriado): agradeça aos que tenham contribuído de maneira significativa para o estudo (pessoas, laboratórios, setores etc).

j) Financiamentos: especifique patrocinadores, auxílios financeiros, bolsas e/ou programas citando o nome da organização de apoio de fomento e o número do processo.

k) Declarações: adicionar, após os agradecimentos, quando houver, as declarações de conflito de interesse e de disponibilidade de dados de pesquisa.

l) Referências (ver item Referências).

Resumo gráfico

Um resumo gráfico é um formato visual do manuscrito para resumir os achados essenciais do estudo. Ajuda a divulgar informações fáceis e concisas, que podem

ser rapidamente incorporadas pelos leitores e ajudam a ser compartilhadas, inclusive nas mídias sociais. Portanto, o JAOS encoraja esta submissão. Uma figura original que indique claramente a sequência descrita no manuscrito precisa ser projetada (JPEG, mínimo de 300 dpi e 1080 x 1080 pixels - largura x altura) e enviada como um arquivo separado.

Exemplos:

https://www.instagram.com/p/CL44dlbF-wu/

https://www.instagram.com/p/CVh4M9aFsGw/

https://www.instagram.com/p/CHhyixyFkag/

Ativos Digitais

As ilustrações (fotografias, gráficos, desenhos, fluxogramas etc.) serão consideradas no texto como figuras, sendo limitadas ao mínimo indispensáveis e devem ser adicionadas em arquivos separados, numeradas consecutivamente em algarismos arábicos, segundo a ordem em que aparecem no texto. Devem apresentar formato .jpg, com no mínimo 300 dpi de resolução e entre 15 cm a 20 cm de largura.

Materiais provenientes de câmeras digitais devem ter no mínimo 3 megapixels de resolução óptica sem compressão (módulo high definition).

As tabelas deverão ser logicamente organizadas, numeradas consecutivamente em algarismos arábicos e a legenda será colocada na parte superior. Devem ser incluídas no texto do manuscrito.

As legendas das ilustrações e os títulos das tabelas deverão ser claros, concisos e localizados ao final do arquivo principal em forma de lista separada e precedidas da numeração correspondente.

As notas de rodapé de ilustrações e tabelas serão indicadas por asteriscos e restritas ao mínimo indispensável.

Citações e Referências

A citação dos autores no texto poderá ser feita de duas maneiras:

1) Somente numérica - As referências devem ser citadas em ordem crescente no parágrafo.

Ex. ... and interfere with the bacterial system and tissue system.3,4,7-10

2) ou alfanumérica:

Um autor: Gatewood31 (2012)

Dois autores: Cotti and Mercuro19 (2016)

Três autores: Azar, Safi, Nikaein27 (2012)

Mais que três autores: Gealh, et al.28 (2014)

Referências

As Referências deverão obedecer aos requisitos "Uniform requirements for manuscripts submitted to Biomedical Journals - Vancouver".

Toda referência deverá ser citada no texto. Elas devem ser ordenadas de acordo com sua apresentação no texto e numeradas sequencialmente em ordem crescente. As abreviaturas dos títulos dos periódicos citados deverão estar de acordo com o padrão MEDLINE.

Não incluir comunicações pessoais e materiais bibliográficos sem data de publicação na lista de referências.

Teses, dissertações, monografias e resumos não serão aceitos como referências, mesmo que apresentem DOI.

Minimizar referências a publicações em línguas que não a inglesa. O título traduzido em inglês deve ser citado entre colchetes e o idioma original inserido no final da referência.

Listar os nomes dos 6 primeiros autores do trabalho; excedendo este número, os 6 primeiros autores do trabalho devem ser citados, seguidos pela expressão "et al." não escrita em itálico e acompanhada por ponto final.

Ex: Cintra LT, Samuel RO, Azuma MM, Ribeiro CP, Narciso LG, Lima VM, et al.

Não ultrapassar a citação de 40 referências.

Exemplos de Referências

Livro

Preedy VR, organizator. Fluorine: chemistry, analysis, function and effects. London: Royal Society of Chemistry; 2015.

Capítulo de livro

Buzalaf CP, Leite AL, Buzalaf MA. Fluoride metabolism. In: Preedy VR, organizator. Fluorine: chemistry, analysis, function and effects. London: Royal Society of Chemistry; 2015. p. 54-72.

Artigo de periódico

Conti PC, Bonjardim LR, Stuginski-Barbosa J, Costa YM, Svensson P. Pain complications of oral implants: Is that an issue? J Oral Rehabil. 2021;48(2):195-206. doi: 10.1111/joor.13112

Artigo de periódico com idioma original que não o inglês

Schubert O, Le V, Probst F. Chancen und Risiken von Zahnimplantaten [Dental implants - opportunities and risks]. MMW Fortschr Med. 2022;164(9):50-2. German. doi: 10.1007/s15006-022-0970-4

Artigo de periódico exclusivamente na Internet (com identificador eletrônico)

Peixoto KO, Resende CM, Almeida EO, Almeida-Leite CM, Conti PC, Barbosa GA, et al. Association of sleep quality and psychological aspects with reports of bruxism and TMD in Brazilian dentists during the COVID-19 pandemic. J Appl Oral Sci [Internet]. 2021 [cited 2022 June 20];29:e20201089. Available from: http://dx.doi.org/10.1590/1678-7757-2020-108

Artigo de periódico com DOI

Francese MM, Gonçalves IV, Vertuan M, Souza BM, Magalhães AC. The protective effect of the experimental TiF4 and chitosan toothpaste on erosive tooth wear in vitro. Sci Rep. 2022;12(1):7088. doi: 10.1038/s41598-022-11261-1

Artigo de periódico Epub ahead of print/In press/Forthcoming

Pucciarelli MG, Toyoshima GH, Oliveira TM, Neppelenbroek KH, Soares S. Quantifying the facial proportions in edentulous individuals before and after rehabilitation with complete dentures compared with dentate individuals: a 3D stereophotogrammetry study. J Prosthet Dent. Forthcoming 2022. doi: 10.1016/j.prosdent.2022.03.013

Preprint

Weissheimer T, Só MV, Alcalde MP, Cortez JB, Rosa RA, Vivan RR, et al. Evaluation of mechanical properties of coronal flaring nickel-titanium instruments. Research Square rs-49258/v1 [Preprint]. 2020 [cited 2020 Sept 2]. Available from: https://doi.org/10.21203/rs.3.rs-49258/v1

Dados de pesquisa

Mahardawi B. The role of hemostatic agents following dental extractions: a systematic review and meta-analysis [dataset]. 2022 Mar 14 [cited 2022 Apr 22]. In: Dryad [Internet]. doi: 10.5061/dryad.59zw3r297. Available from: https://doi.org/10.5061/dryad.59zw3r297

Inteligência artificial

ChatPDF GmbH. What is the significance of beta-defensin 118 in the defense against Candida infection? [artificial intelligence]. GPT-3.5 version 2023 [cited 2023 Oct 19]. Available from: https://www.chatpdf.com/

Artigos com mais de 6 autores

Citam-se até os 6 primeiros seguidos da expressão "et al."

Bergantin BT, Di Leone CC, Cruvinel T, Wang L, Buzalaf MA, Borges AB, et al. S-PRG-based composites erosive wear resistance and the effect on surrounding enamel. Sci Rep. 2022;12(1):833. doi: 10.1038/s41598-021-03745-3

Volume com suplemento e/ou Número Especial

Ricomini AP Filho, Chávez BA, Giacaman RA, Frazão P, Cury JA. Community interventions and strategies for caries control in Latin American and Caribbean countries. Braz Oral Res. 2021;35(suppl 1):e054. doi: 10.1590/1807-3107bor-2021.vol35.0054

A exatidão das referências é de responsabilidade dos autores.

Documentos Suplementares

O Formulário de Submissão, assinado por TODOS os autores, deve ser submetido como arquivo obrigatório.

Formulário sobre Conformidade com a Ciência Aberta DEVE ser submetido como arquivo obrigatório.

Informações Adicionais

Os manuscritos deverão ser submetidos por meio do endereço: https://mc04.manuscriptcentral.com/jaos-scielo