

SEVEN

EDITORIA
2026

Essence of Dentistry

Research and Practice in Oral Health

2ND EDITION



TAÍS ROCHA

EDITOR-IN-CHIEF

Prof^o Me. Isabele de Souza Carvalho

EXECUTIVE EDITOR

Nathan Albano Valente

BOOK ORGANIZER

Taís Rocha

EDITORIAL PRODUCTION

Seven Publicações Ltda

EDITORIAL DESIGNER

Stephanie Caroline Meyer de Quadros

TEXT EDITING

Isabele de Souza Carvalho

TRANSLATION

Isabele de Souza Carvalho

ART EDIT

Evellyn Thais de Souza

LIBRARIAN

Bruna Heller

COVER IMAGES

AdobeStok

2026 by Seven Editora

Copyright © Seven Editora

Text Copyright © 2026 The Authors

Copyright of the 2026 Edition © Seven Editora

The content of the text and its data in its form, correctness, and reliability are the sole responsibility of the authors and do not necessarily represent the official position of Seven Publicações Ltda. The download of the work and sharing it is allowed as long as credits are attributed to the authors but without the possibility of altering it or using it for commercial purposes.

All manuscripts were previously submitted to blind peer review, members of the Editorial Board of this Publisher, and were approved for publication based on criteria of neutrality and academic impartiality.

Seven Publicações Ltda is committed to ensuring editorial integrity at all stages of the publication process, avoiding plagiarism and fraudulent data or results, and preventing financial interests from compromising the publication's ethical standards.

Suspected situations of scientific misconduct will be investigated under the highest standard of academic and ethical rigor.



The contents of this book have been submitted by the authors for open-access publication, under the terms and conditions of the Creative Commons 4.0 International Attribution License

EDITORIAL BOARD

EDITOR-IN-CHIEF

Prof. Me. Isabele de Souza Carvalho

EDITORIAL BOARD

Adriana Barni Truccolo - State University of Rio Grande do Sul
Adriana Barretta Almeida - Federal University of Paraná
Alessandre Gomes de Lima - Faculty of Medicine of the University of Porto
Anderson Nunes Da Silva - Federal University of Northern Tocantins
Antonio da Costa Cardoso Neto - University of Flores Buenos Aires
Antônio Alves de Fontes-Júnior - Cruzeiro do Sul University
Ariane Fernandes da Conceição - Federal University of Triângulo Mineiro
Arnaldo Oliveira Souza Júnior - Federal University of Piauí, CEAD
Caio Vinicius Efigenio Formiga - Pontifical Catholic University of Goiás
Charles Henrique Andrade de Oliveira - University of Pernambuco
Egas José Armando - Eduardo Mondlane University of Mozambique
Inaldo Kley do Nascimento Moraes - State University of Southwest Bahia
Irlane Maia de Oliveira - Federal University of Mato Grosso
Janyel Trevisol - Federal University of Santa Maria
Jorge Fernando Silva de Menezes - University of Aveiro
Jorge Luís Pereira Cavalcante - Iberoamerican University Foundation
Kleber Farinazo Borges - University of Brasília
Luiz Gonzaga Lapa Junior - University of Brasília
Mara Lucia da Silva Ribeiro - Federal University of São Paulo
Marcelo Silva de Carvalho - Federal University of Alfenas
Marcos Garcia Costa Moraes - State University of Paraíba
Maria Gorete Valus - University of Campinas
Mônica Maria de Almeida Brainer - Federal Institute of Goiás Ceres Campus
Moacir Silva de Castro - Pontifical Catholic University of São Paulo
Paulo Roberto Duailibe Monteiro - Fluminense Federal University
Pedro Henrique Ferreira Marçal - Vale do Rio Doce University
Rafael Braga Esteves - University of São Paulo
Telma Regina Stroparo - State University of Ponta Grossa
Valéria Raquel Alcantara Barbosa - Oswaldo Cruz Foundation
Wanderson Santos de Farias - University of Sustainable Development
Yuni Saputri M.A - Nalanda University, India

International Cataloguing in Publication Data (CIP)
(Brazilian Book Chamber, SP, Brazil)

R672e Rocha, Taís.

Essence of Dentistry [recurso eletrônico] : Research and
Practice in Oral Health - 2nd Edition / Taís Rocha. – 2. ed. –
São José dos Pinhais, PR: Editora Seven, 2026.

Dados eletrônicos (1 PDF).

ISBN 978-65-6109-317-0

1. Odontologia. 2. Pesquisa. I. Título.

CDU 616.314

Bruna Heller - Librarian - CRB10/2348

Indexes for systematic catalog:

1 Odontologia 616.314

DOI: 10.56238/sevened2026.021-

Seven Publicações Ltda
CNPJ: 43.789.355/0001-14
editora@sevenevents.com.br
São José dos Pinhais/PR

AUTHOR'S STATEMENT

The author of this work DECLARES, for the following purposes, that:

Do not have any commercial interest that generates a conflict of interest about the published content;

Declares to have actively participated in the construction of the respective manuscripts, preferably under the following conditions: "a) Study design, and/or data acquisition, and/or data analysis and interpretation; b) Preparation of the article or revision to make the material intellectually relevant; c) Final approval of the manuscript for submission";

Certifies that the published text is completely free of data and/or fraudulent results and authorship defects;

Confirms the correct citation and reference of all data and interpretations of data from other surveys;

Acknowledges having informed all the sources of funding received to carry out the research;

Authorizes the editing of the work, including catalog records, ISBN, DOI, and other indexers, visual design and creation of the cover, and internal layout, as well as its release and dissemination according to the criteria of Seven Eventos Acadêmicos and Editora.

EDITOR'S STATEMENT

Seven Publications DECLARES, for rights, duties, and any methodological or legal meanings, that:

This publication constitutes only a temporary transfer of copyright, constituting a right to publication and reproduction of the materials. The Publisher is not co-responsible for the creation of the published manuscripts, under the terms established in the Copyright Law (Law 9610/98), in article 184 of the Penal Code and in article 927 of the Civil Code; The author(s) is solely responsible for verifying such copyright and other issues, holding the Publisher harmless from any civil, administrative, and criminal damages that may arise.

Authorizes the DISCLOSURE OF THE WORK by the author(s) in lectures, courses, events, shows, media, and television, provided that there is due recognition of the authorship and edition and without any commercial purpose, with the presentation of the due CREDITS to SEVEN PUBLICATIONS, being the author(s) and publisher(s) responsible for the omission/exclusion of this information;

All eBooks are open access, so don't sell them on your website, partner sites, e-commerce platforms, or any other virtual or physical medium. Therefore, it is exempt from copyright transfers to authors, since the format does not generate rights other than the didactic and advertising purposes of the work, which can be consulted at any time.

All members of the editorial board are PhDs and linked to public institutions of higher education, as recommended by CAPES to obtain the Qualis book;

Seven Eventos Acadêmicos does not attribute, sell, or authorize the use of the authors' names and e-mails, as well as any other data of them, for any purpose other than the dissemination of this work, following the Civil Rights Framework for the Internet, the General Data Protection Law and the Constitution of the Federative Republic.

AUTHORS

Adalberto Batista de Paula
Alice da Silva Alencar
Ana Beatriz Nunes Santos e Silva Barroso
Ana Caroline Debastiani Mazzochi
Ana Paula de Lima Oliveira
Andressa Alana Locatti Sian
Andreza Calazans Rodrigues
Antoniane Arantes de Oliveira Roque
Antônio Fernando Gentil
Bruna Braga Vela Noronha
Brunno Pereira Silva
Bruno César Batista Assunção
Camila Ventura Feliciano
Cristiane Elisa Ribas Batista
Cristiano Veloso
Cristina Carla Xavier da Silva
Danielle Santos Quindos
Fernanda Castelo Branco Santos Bettero
Fernanda Karla Duailibe Fontes
Gabriell Mafuz Penteado
Giselle Moreira de Carvalho
Guilherme José Lopes de Oliveira
Hellen Cristina Batista Souza
Hercilia Maria Lins Rolim
Isabella Santos Paula
Joelly Pinheiro da Silva
Julia de Araújo Koplowitz Bento
Layreson Teylon Silva Fernandes de Sousa
Lethicia Luiza Rampanelli de Azevedo
Lina Clara Gayoso e Almendra Ibiapina Moreno
Lívia Rodrigues Pinheiro
Luis Fernando dos Santos
Luísa Simões de Albuquerque
Marcelo Vitale
Marcio Luiz Ferro-Alves
Marcos Vinícios Alves de As
Maria Clara de Paula Lima
Maria Eduarda Cardoso Sobral
Maria Eduarda Viana Baron Torres da Costa
Maria Valéria Camargos d'Ávila
Maurício Alves Martins
Mayara Valéria Ferreira Lopes
Noevany Alexandrino de Oliveira Nascimento
Patrícia Gouveia Gomes Câmara
Priscilla Barbosa Ferreira Soares
Rafaella Araújo Amancio de Lima Medeiros

Rebeca Vidal Capelupi
Rebeka Maria de Sousa Feitosa
Renan Carlos Lopes Cavalcante
Renato Mendes Almeida
Ricardo Phillipe Couto de Araújo
Roque Luis Mendes Neto
Rusbene Bruno Fonseca de Carvalho
Sabrina André Silva
Silvia Rebeca Leal Rodrigues
Tayná Ribeiro Monteiro de Figueiredo
Thaís Chacin Muniz
Thaís Cruz Ramalho
Túlio Fernandes de Souza
Veronica Luiza Saviczki
Vinicius Arruda Vasconcelos
Wanúbia Barbosa Nunes
Wilker de Castro Magalhães
William Alves dos Reis
William Augusto Guimarães

BOOK ORGANIZER

Taís Rocha
Lattes: <http://lattes.cnpq.br/7142404842835976>

PRESENTATION

Dentistry is a field of knowledge in which different disciplines intertwine to form a greater whole. **Essence of Dentistry: Research and Practice in Oral Health - 2 ed** is a work that expands this interconnection, together 6 articles on various topics, written by experts from different areas of knowledge.

Developed by **Seven Publications**, this book presents a broad overview of the challenges, discoveries and advances in fields such as genioplasty, osteonecrosis, periodontal structures and much more.

SUMMARY

ADVANCEMENT GENIOPLASTY: COMPARISON BETWEEN SLIDING OSTEOTOMY AND ALLOPLASTIC IMPLANTS

Marcelo Vitale, Cristiane Elisa Ribas Batista, Hellen Cristina Batista Souza, Renan Carlos Lopes Cavalcante, Danielle Santos Quindos, Maurício Alves Martins, Renato Mendes Almeida, Maria Eduarda Viana Baron Torres da Costa, Vinicius Arruda Vasconcelos, Bruna Braga Vela Noronha, Cristiano Veloso, Antônio Fernando Gentil, Marcio Luiz Ferro-Alves, Cristina Carla Xavier da Silva, Ana Beatriz Nunes Santos e Silva Barroso, Andressa Alana Locatti Sian, Veronica Luiza Saviczki, Roque Luis Mendes Neto, Noevany Alexandrino de Oliveira Nascimento, Livia Rodrigues Pinheiro, Patrícia Gouveia Gomes Câmara, Camila Ventura Feliciano, Ana Caroline Debastiani Mazzochi.

  <https://doi.org/10.56238/sevened2026.021-001>

8-17

SURGICAL MANAGEMENT OF MEDICATION-RELATED OSTEONECROSIS OF THE JAW (MRONJ)

Ricardo Phillippe Couto de Araújo, Andreza Calazans Rodrigues, Adalberto Batista de Paula, Mayara Valéria Ferreira Lopes, Gabriell Mafuz Penteado, Thaís Chaein Muniz, Brunno Pereira Silva, Rebeca Vidal Capelupi, Julia de Araújo Koplowitz Bento, Fernanda Karla Duailibe Fontes, Bruno César Batista Assunção, Lethicia Luiza Rampanelli de Azevedo, Wilker de Castro Magalhães, Maria Valéria Camargos d'Ávila, Silvia Rebeca Leal Rodrigues, Túlio Fernandes de Souza, Maria Eduarda Cardoso Sobral, Noevany Alexandrino de Oliveira Nascimento, William Alves dos Reis.

  <https://doi.org/10.56238/sevened2026.021-002>

18-29

COMPONENTS AND PHYSIOLOGY OF PERIODONTAL STRUCTURES

Isabella Santos Paula, Maria Clara de Paula Lima, Fernanda Castelo Branco Santos Bettero, Ana Paula de Lima Oliveira, Guilherme José Lopes de Oliveira, Priscilla Barbosa Ferreira Soares.

  <https://doi.org/10.56238/sevened2026.021-003>

30-57

PROFILE OF MAXILLOFACIAL INJURIES IN WOMEN VICTIMS OF VIOLENCE FROM THE PERSPECTIVE OF FORENSIC ODONTOLOGY IN THE CITY OF JOÃO PESSOA, PARAÍBA

Giselle Moreira de Carvalho, Joelly Pinheiro da Silva, Sabrina André Silva, Rebeka Maria de Sousa Feitosa, Rafaella Araújo Amancio de Lima Medeiros, Luísa Simões de Albuquerque, Wanúbia Barbosa Nunes, Tayná Ribeiro Monteiro de Figueiredo.

  <https://doi.org/10.56238/sevened2026.021-004>

58-77

BEHAVIOR OF THE ORAL AND MAXILLOFACIAL ORTHOPEDIC IMPLANT

Antoniane Arantes de Oliveira Roque, Luis Fernando dos Santos, William Augusto Guimarães.

  <https://doi.org/10.56238/sevened2026.021-005>

78-104

PHOSPHORIC ACID: A PROBLEM TO PEDIATRIC DENTISTRY PATIENTS

Alice da Silva Alencar, Rusbene Bruno Fonseca de Carvalho, Marcos Vinicius Alves de Sa, Lina Clara Gayoso e Almendra Ibiapina Moreno, Thaís Cruz Ramalho, Layreson Teylon Silva Fernandes de Sousa, Hercilia Maria Lins Rolim.

  <https://doi.org/10.56238/sevened2026.021-006>

105-115

ADVANCEMENT GENIOPLASTY: COMPARISON BETWEEN SLIDING OSTEOTOMY AND ALLOPLASTIC IMPLANTS

MENTOPLASTIA DE AVANÇO: COMPARAÇÃO ENTRE OSTEOTOMIA DESLIZANTE E IMPLANTES ALOPLÁSTICOS

MENTOPLASTIA DE AVANCE: COMPARACIÓN ENTRE OSTEOTOMÍA DESLIZANTE E IMPLANTES ALOPLÁSTICOS



<https://doi.org/10.56238/sevened2026.021-001>

Marcelo Vitale¹, Cristiane Elisa Ribas Batista², Hellen Cristina Batista Souza³, Renan Carlos Lopes Cavalcante⁴, Danielle Santos Quindos⁵, Maurício Alves Martins⁶, Renato Mendes Almeida⁷, Maria Eduarda Viana Baron Torres da Costa⁸, Vinicius Arruda Vasconcelos⁹, Bruna Braga Vela Noronha¹⁰, Cristiano Veloso¹¹, Antônio Fernando Gentil¹², Marcio Luiz Ferro-Alves¹³, Cristina Carla Xavier da Silva¹⁴, Ana Beatriz Nunes Santos e Silva Barroso¹⁵, Andressa Alana Locatti Sian¹⁶, Veronica

¹ Dr. in Implant Dentistry. Instituto Orofacial das Américas (IOA). E-mail: marvitale@uol.com.br

² Master's degree in Psychology. Centro Universitário UniDomBosco (UniDomBosco). Instituto Paranaense de Pesquisa e Ensino em Odontologia (IPPEO). Universidade Federal de Santa Catarina (UFSC). E-mail: dracristiane.rbatista@gmail.com

³ Dentist. Universidade Federal de Uberlândia. E-mail: odontocomamor@hotmail.com

⁴ Master's degree in Oral and Maxillofacial Surgery. Universidade Federal do Rio de Janeiro (UFRJ). E-mail: drenancavalcante@gmail.com

⁵ Specialist in Orthodontics, Pediatric Dentistry and Special Needs Patients. Universidade Estadual do Amazonas (UEA). E-mail: danielle.quindos@gmail.com

⁶ Undergraduate student in Dentistry. Universidade Federal de Pernambuco (UFPE). E-mail: mauricio.martins@ufpe.br

⁷ Master's degree in Bioengineering. Faculdade Federal de Odontologia de Diamantina (FAFEOD). Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM). E-mail: renatoimplante@yahoo.com.br

⁸ Undergraduate student in Dentistry. Centro Universitário de Cascavel (UNIVEL). E-mail: mah.baron@hotmail.com

⁹ Resident in Oral and Maxillofacial Surgery and Traumatology. Hospital Fornecedores de Cana de Piracicaba (HFC Saúde). E-mail: vinicius.odonto.ctbmf@gmail.com

¹⁰ Implantologist. Universidade Nilton Lins. E-mail: drabrunabragaa@hotmail.com

¹¹ Master's degree in Dental Medicine. Universidade Federal Fluminense (UFF). Faculdade Paulo Picanço. Instituto Universitário Egas Moniz. E-mail: veloso.cristiano@icloud.com

¹² Dentist. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). E-mail: odontododoc@gmail.com

¹³ Master's degree in Dentistry. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). E-mail: drmarcioluizferroalves@gmail.com

¹⁴ Specialist in Implant Dentistry, Prosthodontics and Orthodontics. Resident in Oral and Maxillofacial Surgery and Traumatology. Universidade Tuiuti do Paraná. Pontifícia Universidade Católica do Paraná (PUC-PR). E-mail: cris.xavier@msn.com

¹⁵ Dentist. Specialist in Implantology. Specialist in Orofacial Harmonization. Training in Nitrous Oxide Sedation. Faculdade Herrero. Facsete. Faculdade Faípe. Centro Universitário do Triângulo (UNITRI). E-mail: abnunes94@gmail.com

¹⁶ Dentist. Universidade Nove de Julho (UNINOVE). E-mail: dra.andressalocatti@icloud.com

Luiza Saviczki¹⁷, Roque Luis Mendes Neto¹⁸, Noevany Alexandrino de Oliveira Nascimento¹⁹, Livia Rodrigues Pinheiro²⁰, Patrícia Gouveia Gomes Câmara²¹, Camila Ventura Feliciano²², Ana Caroline Debastiani Mazzochi²³

ABSTRACT

Advancement genioplasty is a widely used procedure in facial harmonization, aiming to correct chin deformities such as microgenia, thereby contributing to the aesthetic and functional balance of the lower third of the face. Among the available techniques, sliding genioplasty and alloplastic chin implants stand out, each presenting distinct indications, advantages, and complication profiles. This study aimed to perform a narrative literature review with a qualitative approach, comparing these two techniques regarding their indications, outcomes, and complications. The literature search was conducted in PubMed, SciELO, and ScienceDirect databases, including articles published within the last ten years. A total of 15 relevant studies were selected, comprising systematic reviews, clinical studies, and literature reviews. The findings demonstrated that both techniques provide high patient satisfaction rates and satisfactory aesthetic outcomes. However, sliding genioplasty showed greater predictability and long-term stability, being more suitable for moderate to severe deformities and cases requiring three-dimensional correction. In contrast, alloplastic implants were associated with lower invasiveness, shorter operative time, and faster recovery, being more appropriate for mild to moderate cases. Regarding complications, implants were more frequently associated with infections, extrusion, and bone resorption, whereas sliding genioplasty was mainly related to neurosensory alterations, which are generally transient. It can be concluded that both techniques are effective, with no absolute superiority between them, and the choice should be based on individualized patient assessment and careful surgical planning.

Keywords: Genioplasty. Chin Augmentation. Sliding Genioplasty. Alloplastic Implants. Microgenia. Facial Aesthetics.

RESUMO

A mentoplastia de avanço é um procedimento amplamente utilizado na harmonização facial, com o objetivo de corrigir deformidades do mento, como a microgenia, contribuindo para o equilíbrio estético e funcional do terço inferior da face. Dentre as técnicas disponíveis, destacam-se a genioplastia por osteotomia deslizante e a utilização de implantes aloplásticos, que apresentam diferentes indicações, vantagens e perfis de complicações. O

¹⁷ Dentist; Specialist in Endodontics. Universidade de Cuiabá (UNIC). Associação Brasileira de Odontologia (ABO-MT). E-mail: vehluiza@gmail.com

¹⁸ Graduated in Dentistry. Faculdade Maurício de Nassau (UNINASSAU). E-mail: roquelmn@gmail.com

¹⁹ Undergraduate student in Dentistry. Universidade de Cuiabá. E-mail: noealexandrino@gmail.com

²⁰ Undergraduate student in Dentistry. ATITUS Educação. E-mail: lirodriguespinheiro@gmail.com

²¹ Master's degree in Health Management. Faculdade de Odontologia de Pernambuco da Universidade de Pernambuco (FOP-UPE). MUST University. Centro Universitário Avantis (UniAvantis). Faculdade de Ensino Superior do Nordeste (UNIFUTURO). E-mail: patriciaggcamara@icloud.com

²² Undergraduate student in Dentistry. Faculdade Maurício de Nassau (UNINASSAU). E-mail: miilaventura12@gmail.com

²³ Master student in Community Development. Centro Universitário Guairacá (UniGuairacá). Universidade Estadual do Centro-Oeste (UNICENTRO). E-mail: anamazzochiodonto@gmail.com

presente estudo teve como objetivo realizar uma revisão narrativa da literatura, de abordagem qualitativa, a fim de comparar essas duas técnicas quanto às suas indicações, resultados e complicações. A busca bibliográfica foi realizada nas bases de dados PubMed, SciELO e ScienceDirect, incluindo artigos publicados nos últimos dez anos. Foram selecionados 15 estudos relevantes, entre revisões sistemáticas, estudos clínicos e revisões de literatura. Os resultados evidenciaram que ambas as técnicas apresentam elevada taxa de satisfação dos pacientes e resultados estéticos satisfatórios. No entanto, a osteotomia deslizante demonstrou maior previsibilidade e estabilidade a longo prazo, sendo mais indicada em casos de deformidades moderadas a severas e alterações tridimensionais. Em contrapartida, os implantes aloplásticos destacaram-se pela menor invasividade, menor tempo cirúrgico e recuperação mais rápida, sendo mais indicados em casos leves a moderados. Em relação às complicações, os implantes apresentaram maior associação com eventos infecciosos, extrusão e reabsorção óssea, enquanto a osteotomia esteve mais relacionada a alterações neurossensoriais, geralmente transitórias. Conclui-se que ambas as técnicas são eficazes, não havendo superioridade absoluta entre elas, sendo a escolha dependente da avaliação individualizada do paciente e do adequado planejamento cirúrgico.

Palavras-chave: Mentoplastia. Genioplastia. Osteotomia Deslizante. Implantes Aloplásticos. Microgenia. Harmonização Facial.

RESUMEN

La mentoplastia de avance es un procedimiento ampliamente utilizado en la armonización facial, cuyo objetivo es corregir deformidades del mentón, como la microgenia, contribuyendo al equilibrio estético y funcional del tercio inferior del rostro. Entre las técnicas disponibles, destacan la genioplastia con osteotomía deslizante y el uso de implantes aloplásticos, que presentan diferentes indicaciones, ventajas y perfiles de complicaciones. Este estudio tuvo como objetivo realizar una revisión narrativa de la literatura, con un enfoque cualitativo, para comparar estas dos técnicas en cuanto a sus indicaciones, resultados y complicaciones. La búsqueda bibliográfica se realizó en las bases de datos PubMed, SciELO y ScienceDirect, incluyendo artículos publicados en los últimos diez años. Se seleccionaron quince estudios relevantes, entre ellos revisiones sistemáticas, estudios clínicos y revisiones de la literatura. Los resultados mostraron que ambas técnicas presentan un alto índice de satisfacción del paciente y resultados estéticos satisfactorios. Sin embargo, la osteotomía deslizante demostró mayor predictibilidad y estabilidad a largo plazo, estando más indicada en casos de deformidades moderadas a severas y alteraciones tridimensionales. En contraste, los implantes aloplásticos destacaron por su menor invasividad, menor tiempo quirúrgico y recuperación más rápida, lo que los hace más adecuados para casos leves a moderados. En cuanto a las complicaciones, los implantes mostraron una mayor asociación con infecciones, extrusión y reabsorción ósea, mientras que la osteotomía se relacionó más con alteraciones neurossensoriales, generalmente transitorias. Se concluye que ambas técnicas son efectivas, sin que exista una superioridad absoluta entre ellas; la elección depende de la evaluación individualizada del paciente y de una planificación quirúrgica adecuada.

Palabras clave: Mentoplastia. Genioplastia. Osteotomía Deslizante. Implantes Aloplásticos. Microgenia. Armonización Facial.

1 INTRODUCTION

Facial harmony is the result of the adequate proportion between the anatomical structures of the face, and the chin is one of the main determinants of the aesthetic balance of the lower third of the face. Changes in the projection, shape, or position of the chin can significantly compromise the facial profile, leading to the indication of corrective surgical procedures, such as advance mentoplasty (genioplasty) (SHOKRI et al., 2021). In this context, genioplasty allows three-dimensional modifications of the chin, and is widely used for both aesthetic and functional purposes, especially in cases of microgeny and dentofacial deformities (FERRETTI; REYNEKE, 2016).

Among the main techniques available for chin augmentation, bone genioplasty by sliding osteotomy and the use of alloplastic implants stand out. Sliding osteotomy enables the mobilization of the mandibular bone segment, allowing corrections in multiple spatial planes, while alloplastic implants promote volume increase through the insertion of synthetic materials, such as silicone or porous polyethylene (KAUKE-NAVARRO et al., 2025; SHOKRI et al., 2021). The choice of technique depends on factors such as the magnitude of the deformity, the patient's anatomical characteristics, and aesthetic expectations.

Recent literature shows that both techniques are effective in correcting microgeny, presenting high rates of patient satisfaction. However, important differences are observed in terms of the predictability of the results and the profile of complications. Studies indicate that bone genioplasty has greater predictability in soft tissue response and greater long-term stability when compared to alloplastic implants (KAUKE-NAVARRO et al., 2025; BERTOSSI et al., 2015). On the other hand, alloplastic implants stand out for being less invasive procedures and simpler to perform, with less surgical time.

With regard to complications, it is observed that alloplastic implants are more frequently associated with events such as infection, extrusion, displacement, and adjacent bone resorption, although they generally have low morbidity (LIAO et al., 2023; SCIARAFFIA et al., 2018). On the other hand, osteotomy genioplasty is more related to neurosensory changes in the chin nerve, which are usually transitory, in addition to possible bone irregularities and recurrence in a smaller proportion (KAUKE-NAVARRO et al., 2025; ORANGES et al., 2022). Thus, each technique has specific advantages and limitations, which must be carefully considered in surgical planning.

Given these differences, the choice between sliding osteotomy and alloplastic implants must be individualized, considering not only the anatomical and functional aspects, but also the risks, benefits, and expectations of the patient. Thus, the present study aims to review the literature on advancement mentoplasty, comparing sliding osteotomy and alloplastic

implants regarding their indications, results, and complications, contributing to clinical decision-making based on up-to-date scientific evidence.

2 METHODOLOGY

The present study is characterized as a narrative review of the literature, with a qualitative approach, with the objective of analyzing and comparing the techniques of advancement mentoplasty by means of sliding osteotomy and alloplastic implants, considering their indications, results and complications.

The bibliographic search was carried out in the PubMed, SciELO and ScienceDirect databases, recognized for their relevance in the health area, from January to March 2026. English descriptors were used, combined by Boolean operators (AND and OR), according to the following search strategy: ("genioplasty" OR "chin augmentation") AND ("sliding genioplasty" OR "alloplastic implants" OR "chin implants" OR "microgenia"). Articles published in the last ten years, in English and Portuguese, were considered in order to ensure the updating of scientific evidence.

As inclusion criteria, we selected articles available in full, published in indexed journals, that directly addressed advancement mentoplasty and presented data related to the comparison between sliding osteotomy and alloplastic implants, including clinical studies, systematic reviews, and literature reviews. Duplicate articles, studies unrelated to the proposed theme, and publications that did not present relevant data for the comparative analysis of the techniques were excluded.

After applying the eligibility criteria, the titles and abstracts were read for the initial screening of the studies, followed by the complete reading of the selected articles. At the end of the process, 15 articles considered relevant to the construction of this review were included. The selected studies were analyzed descriptively, focusing on the identification of the main characteristics of the techniques addressed, their clinical indications, advantages, limitations, and associated complications.

The data analysis was conducted in a qualitative, descriptive and comparative manner, seeking to critically synthesize the evidence available in the literature and establish a reasoned discussion about the differences between sliding osteotomy techniques and alloplastic implants. As this was a narrative review, no formal assessment of the risk of bias of the included studies was performed, nor was there a statistical analysis of the data.

3 RESULTS AND DISCUSSION

3.1 INDICATIONS OF TECHNIQUES

The choice of the technique for advancement mentoplasty should consider the complexity of the deformity and the need for three-dimensional correction of the chin. The literature shows that sliding osteotomy genioplasty is more versatile, being indicated mainly in cases of moderate to severe microgeny, asymmetries, and associated vertical changes, since it allows precise bone repositioning in multiple planes (BERTOSSl et al., 2015; KAUKE-NAVARRO et al., 2025).

On the other hand, alloplastic implants are more indicated for mild to moderate deformities, in which the main objective is volumetric increase without the need for significant structural repositioning. Studies have shown that this technique has less operative complexity and shorter surgical time, and is often chosen in isolated aesthetic contexts (SHOKRI et al., 2021; O'REILLY et al., 2022).

In addition, contemporary approaches suggest that the therapeutic choice can also be influenced by the magnitude of the desired advancement, with advances greater than 6 mm tending to present better results when performed by means of osteotomies, while smaller increases can be adequately treated with implants (SELAMIOĞLU; KÜÇÜKER, 2024). Thus, there is a trend in the literature towards individualization of indications, based on anatomical and functional criteria.

3.2 AESTHETIC RESULTS AND PREDICTABILITY

The aesthetic results of advancement mentoplasty are largely satisfactory regardless of the technique employed, with high acceptance rates reported in the literature. However, important differences are observed in relation to the predictability and stability of the results. Bone genioplasty has a higher correlation between bone displacement and soft tissue response, with conversion rates that can reach approximately 85%, indicating greater aesthetic predictability (KAUKE-NAVARRO et al., 2025).

In addition, studies have shown that sliding osteotomy provides greater long-term stability, since it promotes definitive structural repositioning of the chin, reducing the dependence on the integration of alloplastic materials (BERTOSSl et al., 2015). In a complementary analysis, systematic reviews indicate that the soft tissue response after genioplasty has a proportional relationship with bone displacement, although slight recurrence may occur, especially in vertical movements (GEORGE et al., 2021).

On the other hand, alloplastic implants present good immediate aesthetic results, but with less predictability in the adaptation of soft tissues, since they depend on the interface

between the biomaterial and the bone bed. Even so, recent advances, such as the use of personalized implants, have shown improvement in adaptation and aesthetic results (GUO et al., 2024).

3.3 COMPLICATIONS

The complication profile represents one of the main distinguishing factors between the techniques. Alloplastic implants are most often associated with infectious and mechanical complications, including infection, extrusion, displacement, and the need for surgical reintervention (LIAO et al., 2023). In addition, bone resorption under the implant is a relatively frequent, although usually asymptomatic, phenomenon, and can reach different degrees of depth over time (SCIARAFFIA et al., 2018).

Comparative studies also indicate that the rate of complications related to implants may vary according to the material used, and porous biomaterials have better tissue integration, but with an increased risk of paresthesia compared to silicone (LIAO et al., 2022; ABDELMABOOD et al., 2022).

In contrast, osteotomy genioplasty has a higher incidence of sensorineural alterations resulting from the manipulation of the chin nerve, which can occur in most patients in the immediate postoperative period, with progressive resolution in most cases (KAUKE-NAVARRO et al., 2025). Other complications include irregularities in the mandibular contour and recurrence, although less frequently when compared to implant complications (ORANGES et al., 2022).

Thus, it is observed that, while implants present a higher risk of infectious and structural complications, osteotomy is more associated with transient sensorineural complications.

3.4 ADVANTAGES AND LIMITATIONS

The comparative analysis of the techniques shows that sliding osteotomy genioplasty has advantages related to its versatility, predictability, and long-term stability. This technique allows three-dimensional corrections and precise adaptation to the patient's anatomical needs, and is considered the most complete approach for complex deformities (BERTOSS I et al., 2015; BAUS et al., 2017).

However, it is a more invasive procedure, with longer surgical time and greater dependence on technical skill, in addition to the risk of neurosensory alterations. On the other hand, alloplastic implants stand out for their technical simplicity, shorter operative time, and faster recovery, and are widely used in isolated aesthetic procedures (SHOKRI et al., 2021).

However, its limitations include lower three-dimensional correction capacity, dependence on biomaterial, and higher risk of late complications, such as infection and extrusion (LIAO et al., 2023). Thus, none of the techniques can be considered superior in all aspects, and the choice depends on the clinical context.

3.5 CLINICAL SELECTION CRITERIA

The contemporary literature emphasizes the importance of individualizing the therapeutic choice, considering factors such as the degree of chin deficiency, the presence of asymmetries, the thickness of the soft tissues, and the patient's expectations. In cases of more complex deformities or significant advances, bone genioplasty is generally preferred due to its greater predictability and stability (BERTOSSA et al., 2015; KAUKE-NAVARRO et al., 2025).

On the other hand, alloplastic implants are an effective alternative in selected cases, especially when there is a need for less invasive procedures or when the objective is predominantly aesthetic (O'REILLY et al., 2022).

In addition, new hybrid approaches, associating grafts or complementary techniques, have been proposed as a way to optimize results, demonstrating the continuous evolution of mentoplasty techniques (GUYURON et al., 2023).

Thus, the clinical decision should be based on a careful and individualized evaluation, considering the patient's characteristics and the available scientific evidence.

4 CONCLUSION

Advancement mentoplasty is a fundamental procedure in the harmonization of the lower third of the face, with high efficacy in the correction of chin deformities. The analysis of the literature shows that both genioplasty by sliding osteotomy and alloplastic implants are capable of providing satisfactory aesthetic results, with high rates of acceptance by patients. However, significant differences are observed between the techniques with regard to the predictability of the results, long-term stability, and complication profile.

Sliding osteotomy genioplasty demonstrates greater versatility and predictability, since it allows precise three-dimensional corrections and has greater structural stability over time. In addition, it is more indicated in cases of moderate to severe deformities, asymmetries and vertical alterations, configuring itself as the technique of choice in more complex situations. On the other hand, alloplastic implants stand out for their lower invasiveness, shorter surgical time, and faster recovery, being an effective alternative in mild to moderate cases, especially when the objective is predominantly aesthetic.

With regard to complications, it is observed that alloplastic implants are more frequently associated with infectious and mechanical events, such as extrusion, displacement, and bone resorption, while sliding osteotomy has a higher incidence of neurosensory alterations, usually transitory. Thus, each technique has a specific profile of risks and benefits, and it is not possible to establish absolute superiority between them.

In view of the available evidence, the choice of technique should be individualized, considering the magnitude of the deformity, the anatomical characteristics of the patient, the aesthetic expectations, and the risk profile of each procedure. Adequate surgical planning and the correct therapeutic indication are crucial for obtaining predictable and satisfactory results.

Finally, the need for additional studies with greater methodological standardization and long-term follow-up is highlighted, in order to improve the understanding of the results and complications associated with the different techniques, reinforcing the fundamental role of therapeutic individualization in obtaining safe, predictable, and long-lasting aesthetic results.

REFERENCES

- Abdelmabood, M. M., & Abdullah, W. A. (2022). Clinical evaluation of genioplasty with either Silastic or Medpor implants. *Journal of Craniofacial Surgery*, 33(5), e456–e460.
- Baus, A., et al. (2017). Prosthetic genioplasty versus osseous genioplasty in aesthetic chin augmentation: Literature review and knowledge update. *Annales de Chirurgie Plastique Esthétique*, 62(6), 510–517.
- Bertossi, D., et al. (2015). Chin microgenia: A clinical comparative study. *Aesthetic Plastic Surgery*, 39(5), 651–659.
- George, R., et al. (2021). Soft tissue response to genioplasty: A systematic review. *Journal of Oral and Maxillofacial Surgery*, 79(2), 345–353.
- Guo, Y., & Ng, R. (2024). Custom-made implant fabrication for chin augmentation. *Journal of Craniofacial Surgery*, 35(1), 112–118.
- Guyuron, B., & Wells, J. H. (2023). The versatile role of fat injection during various genioplasty procedures. *Plastic and Reconstructive Surgery*, 151(3), 654–662.
- Kauke-Navarro, D., et al. (2025). Implant-based chin augmentation versus osseous genioplasty: A systematic review. *Journal of Cranio-Maxillofacial Surgery*, 53(2), 145–154.
- Liao, Y., et al. (2023). Complications following alloplastic chin augmentation: A systematic review. *Aesthetic Plastic Surgery*, 47(2), 789–798.
- Liao, Y., et al. (2022). A systematic review of alloplastic materials used in chin augmentation. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, 75(4), 1201–1210.

- O'Reilly, R., et al. (2022). Chin augmentation with implants: Outcomes and complications in a large cohort. *Plastic and Reconstructive Surgery*, 149(4), 987–995.
- Oranges, C. M., et al. (2022). Chin augmentation techniques: A systematic review. *Aesthetic Plastic Surgery*, 46(1), 123–135.
- Sciaraffia, C. E., et al. (2018). Bone resorption after use of silicone chin implants: Long-term follow-up study with lateral chin radiography. *Plastic and Reconstructive Surgery Global Open*, 6(7), e1850.
- Selamioğlu, Z., & Küçüker, I. (2024). Hybrid chin advancement combining fat and sliced implant techniques. *Journal of Craniofacial Surgery*, 35(2), 220–225.
- Shokri, T., et al. (2021). Genioplasty and mandibular implants. *Facial Plastic Surgery*, 37(6), 709–715.
- Tabrizi, R., et al. (2023). Osseous genioplasty versus chin implants: Early complications and patient satisfaction. *Journal of Oral and Maxillofacial Surgery*, 81(3), 456–462.

SURGICAL MANAGEMENT OF MEDICATION-RELATED OSTEONECROSIS OF THE JAW (MRONJ)

MANEJO CIRÚRGICO DA OSTEONECROSE DOS MAXILARES ASSOCIADA A MEDICAMENTOS (MRONJ)

TRATAMIENTO QUIRÚRGICO DE LA OSTEONECROSIS MANDIBULAR INDUCIDA POR FÁRMACOS (MRONJ)



<https://doi.org/10.56238/sevened2026.021-002>

Ricardo Phillipe Couto de Araújo¹, Andreza Calazans Rodrigues², Adalberto Batista de Paula³, Mayara Valéria Ferreira Lopes⁴, Gabriell Mafuz Penteado⁵, Thaís Chaein Muniz⁶, Brunno Pereira Silva⁷, Rebeca Vidal Capelupi⁸, Julia de Araújo Koplowitz Bento⁹, Fernanda Karla Duailibe Fontes¹⁰, Bruno César Batista Assunção¹¹, Lethicia Luiza Rampanelli de Azevedo¹², Wilker de Castro Magalhães¹³, Maria Valéria Camargos d'Ávila¹⁴, Silvia Rebeca Leal Rodrigues¹⁵, Túlio Fernandes de Souza¹⁶, Maria Eduarda Cardoso Sobral¹⁷, Noevany Alexandrino de Oliveira Nascimento¹⁸, William Alves dos Reis¹⁹

¹ Postgraduate student in Orthodontics and Dentofacial Orthopedics. 2nd-year Resident in Oral and Maxillofacial Surgery and Traumatology. Estácio Recife. E-mail: ricardocoutocirurgia@gmail.com

² Endodontist. Instituto Nacional de Ciências Odontológicas (INCO25). E-mail: calazansand@gmail.com

³ Dentist. Centro Universitário Arnaldo Janssen (UNIARNALDO). E-mail: odonto.adalberto@gmail.com

⁴ Graduated in Dentistry. Faculdade Integrada da Amazônia (FINAMA). E-mail: maylops.new@gmail.com

⁵ Dentist. Universidade Positivo. E-mail: gabriellpenteado.penteado@gmail.com

⁶ Specialist in Hospital Dentistry. Instituto Israelita de Ensino e Pesquisa Albert Einstein. E-mail: thaischaein@hotmail.com

⁷ Master's degree in Clinical Dentistry. Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM). E-mail: brunnipanema@gmail.com

⁸ Master student in Clinical Dentistry. Universidade Federal de Juiz de Fora (UFJF). E-mail: rvcapelupi@gmail.com

⁹ Specialist in Implant Dentistry. Universidade Federal Fluminense (UFF); São Leopoldo Mandic. E-mail: juliaakoplowitz@gmail.com

¹⁰ Dentist. Universidade Ceuma (UNICEUMA). E-mail: nadaduailibe@yahoo.com.br

¹¹ Master student in Radiology and Imaging. Universidade Federal do Piauí (UFPI). E-mail: bssinha@hotmail.com

¹² Dentist. Centro Universitário Facvest (UNIFACVEST). E-mail: rampanellilethicia@gmail.com

¹³ Dentist. Centro Universitário Maurício de Nassau (UNINASSAU). E-mail: wcmagalhaes@yahoo.com.br

¹⁴ Master student in University Teaching. Universidade Federal de Minas Gerais (UFMG); São Leopoldo Mandic. Assero. E-mail: mvaleriadavila@gmail.com

¹⁵ Master student. São Leopoldo Mandic. E-mail: rebecaaleal@hotmail.com

¹⁶ Specialist in Implant Dentistry. Universidade do Estado do Rio de Janeiro (UERJ). E-mail: tuliof006@gmail.com

¹⁷ Undergraduate student in Dentistry. Centro Universitário Maurício de Nassau (UNINASSAU). E-mail: m.eduardasobral00@gmail.com

¹⁸ Dentist. Universidade de Cuiabá. E-mail: noealexandrino@gmail.com

¹⁹ Postgraduate in Restorative Dentistry and Orthodontics. Universidade do Estado do Rio de Janeiro (UERJ). E-mail: wireis@hotmail.com

ABSTRACT

Medication-related osteonecrosis of the jaw (MRONJ) is a pathological condition with multifactorial etiology, commonly associated with the use of antiresorptive and antiangiogenic drugs. This study aimed to analyze, through an integrative literature review, the scientific evidence regarding the surgical management of MRONJ, focusing on indications, techniques, and clinical outcomes. The bibliographic search was conducted in scientific databases, including studies published between 2016 and 2025. Clinical studies, systematic reviews, and guidelines addressing surgical treatment were included. The findings demonstrated that surgical management is more effective than conservative approaches, particularly in advanced stages, and is strongly associated with complete removal of necrotic tissue. More extensive surgical techniques showed higher success rates, although the choice of procedure should be individualized. Adjunctive therapies have shown promising results but still lack standardization. Additionally, a shift in clinical guidelines toward early surgical intervention was observed. It is concluded that surgical treatment represents the main therapeutic strategy for MRONJ, and further high-level evidence studies are needed to establish standardized clinical protocols.

Keywords: Osteonecrosis of the Jaw. MRONJ. Surgical Treatment. Oral and Maxillofacial Surgery.

RESUMO

A osteonecrose dos maxilares associada a medicamentos (MRONJ) é uma condição patológica de etiologia multifatorial, frequentemente relacionada ao uso de fármacos antirreabsortivos e antiangiogênicos. O presente estudo teve como objetivo analisar, por meio de uma revisão integrativa da literatura, as evidências científicas acerca do manejo cirúrgico da MRONJ, com ênfase nas indicações, técnicas e resultados clínicos. A busca bibliográfica foi realizada em bases de dados científicas, considerando estudos publicados entre 2016 e 2025. Foram incluídos artigos clínicos, revisões sistemáticas e diretrizes que abordassem o tratamento cirúrgico da doença. Os resultados evidenciaram que a abordagem cirúrgica apresenta maior eficácia quando comparada ao tratamento conservador, especialmente em estágios avançados, estando diretamente associada à remoção completa do tecido necrótico. Técnicas mais extensas demonstraram melhores taxas de sucesso, embora a escolha do procedimento deva ser individualizada. O uso de terapias adjuvantes mostrou-se promissor, porém ainda carece de padronização. Além disso, observou-se uma mudança nas diretrizes clínicas, com maior indicação de intervenções cirúrgicas precoces. Conclui-se que o tratamento cirúrgico representa a principal estratégia terapêutica na MRONJ, sendo necessário o desenvolvimento de estudos com maior nível de evidência para consolidação dos protocolos clínicos.

Palavras-chave: Osteonecrose dos Maxilares. MRONJ. Tratamento Cirúrgico. Cirurgia Bucomaxilofacial.

RESUMEN

La osteonecrosis mandibular asociada a fármacos (ONMF) es una patología de etiología multifactorial, frecuentemente relacionada con el uso de fármacos antirresorptivos y antiangiogénicos. Este estudio tuvo como objetivo analizar, mediante una revisión bibliográfica integradora, la evidencia científica sobre el tratamiento quirúrgico de la ONMF, con énfasis en las indicaciones, las técnicas y los resultados clínicos. La búsqueda bibliográfica se realizó en bases de datos científicas, considerando estudios publicados entre 2016 y 2025. Se incluyeron artículos clínicos, revisiones sistemáticas y guías que abordan el tratamiento quirúrgico de la enfermedad. Los resultados mostraron que el abordaje quirúrgico es más efectivo que el tratamiento conservador, especialmente en estadios avanzados, al estar directamente asociado con la eliminación completa del tejido necrótico.

Las técnicas más extensas demostraron mejores tasas de éxito, aunque la elección del procedimiento debe individualizarse. El uso de terapias adyuvantes ha mostrado resultados prometedores, pero aún carece de estandarización. Además, se observó un cambio en las guías clínicas, con una mayor indicación de intervenciones quirúrgicas tempranas. Se concluye que el tratamiento quirúrgico representa la principal estrategia terapéutica en la osteonecrosis maxilar relacionada con medicamentos (MRONJ), y se requieren estudios adicionales con un mayor nivel de evidencia para consolidar los protocolos clínicos.

Palabras clave: Osteonecrosis Maxilar. MRONJ. Tratamiento Quirúrgico. Cirugía Oral y Maxilofacial.

1 INTRODUCTION

Medication-Related Osteonecrosis of the Jaw (MRONJ) is a pathological condition characterized by persistent bone exposure or the presence of fistulas that communicate with the bone in the maxillofacial region, in patients undergoing the use of antiresorptive and/or antiangiogenic drugs, in the absence of a history of local radiotherapy (BEDOGNI et al., 2024; DE CICCIO et al., 2023). Initially described in the early 2000s in association with the use of bisphosphonates, the MRONJ had its etiological spectrum broadened with the introduction of other drugs, such as denosumab and antiangiogenic agents, consolidating itself as a relevant complication in dental and medical clinical practice (ÖZALP et al., 2021; DE CICCIO et al., 2023).

From the pathophysiological point of view, RONJ has a multifactorial etiology, involving the suppression of bone remodeling, the inhibition of osteoclastic activity, the impairment of angiogenesis, and the maintenance of chronic inflammatory processes, often associated with local triggering factors, such as tooth extractions and odontogenic infections (OH; KIM, 2024; DE CICCIO et al., 2023). In addition, systemic factors and local conditions, such as periodontal diseases and poor oral hygiene, contribute significantly to the development and progression of the disease, evidencing the complexity of its pathogenesis (BEDOGNI et al., 2024).

Clinically, ONJM has a wide variability of manifestations, and can progress from asymptomatic stages to advanced stages with severe pain, infection, extensive bone exposure, and significant functional impairment, negatively impacting the quality of life of patients (BEDOGNI et al., 2024; DE CICCIO et al., 2023). The diagnosis is based on the correlation between clinical findings and imaging tests, and computed tomography is essential for the evaluation of the extent of the lesion, staging, and appropriate therapeutic planning (BEDOGNI et al., 2024).

Historically, the management of RONJ has been based on conservative approaches, focusing on symptom control and prevention of disease progression. However, such strategies have demonstrated important limitations, especially in advanced stages, in which the rate of complete resolution is reduced (OH; KIM, 2024). Recent clinical studies and reviews show that surgical treatment, particularly when it involves the complete removal of necrotic bone, has superior healing rates and infection control, making it the most effective approach in these cases (ÖZALP et al., 2021; KOBAYASHI et al., 2022; HSU et al., 2021). This paradigm shift reflects the growing understanding of the limitations of conservative treatment and the need for more resolute interventions.

In this context, there is a contemporary trend towards earlier indication of surgical treatment, often associated with adjuvant therapies, such as the use of platelet concentrates, which contribute to tissue regeneration and improved clinical outcomes (DE CICCIO et al., 2023; ÖZALP et al., 2021). Therefore, the present study aims to analyze, through an integrative literature review, the scientific evidence on the surgical management of osteonecrosis of the jaws associated with medications, emphasizing its indications, techniques, and clinical results.

2 METHODOLOGY

This is a qualitative study, characterized as an integrative review of the literature, whose objective is to gather, critically analyze and synthesize the available scientific evidence on the surgical management of drug-associated osteonecrosis of the jaws (MRONJ). The choice of this methodological design is justified by its ability to integrate results from different types of studies, including clinical research, systematic reviews, meta-analyses and guidelines, enabling a comprehensive and in-depth understanding of the investigated theme.

The bibliographic search was conducted in widely recognized scientific databases, including PubMed/MEDLINE, Scopus, Embase and Web of Science, using controlled descriptors and keywords in English. The search strategy was structured based on the combination of the following terms: ("medication-related osteonecrosis of the jaw" OR "MRONJ") AND ("surgical management" OR "surgery" OR "treatment"), with the use of the Boolean operators AND and OR. The established time frame comprised the period from 2016 to 2025, with the objective of contemplating updated scientific evidence in line with contemporary trends in the management of the disease.

The inclusion criteria included original scientific articles, systematic reviews, meta-analyses, and clinical guidelines that directly addressed the surgical management of MRONJ in humans, available in full and published in English. Duplicate studies, experimental research in animal models, isolated case reports, conference abstracts, letters to the editor, and publications that did not adhere to the proposed objective were excluded. The definition of these criteria sought to ensure the selection of evidence with greater scientific relevance and clinical applicability.

The study selection process was carried out sequentially and carefully. Initially, the screening was carried out by reading the titles and abstracts, in order to identify potentially relevant publications. Subsequently, the selected studies were submitted to full reading, including those that fully met the previously established criteria. At the end of the process, 16

studies considered pertinent to the theme were included, which make up the corpus of this integrative review, covering different methodological designs and levels of scientific evidence.

Data analysis was conducted using a descriptive and interpretative approach, with organization of findings into previously defined thematic categories, including pathophysiology of ONJM, diagnostic criteria, indications for surgical treatment, surgical techniques, adjuvant therapies, and clinical outcomes. This systematization allowed the comparison between different therapeutic approaches, as well as the identification of patterns, convergences, and gaps in the literature, contributing to a consistent critical analysis guided by the available evidence.

3 RESULTS AND DISCUSSION

3.1 SURGICAL MANAGEMENT OF MRONJ

The studies included in this review consistently demonstrate that surgical management of drug-associated osteonecrosis of the jaws (RONJM) is more effective when compared to conservative approaches, especially in advanced stages of the disease. Evidence from clinical studies and systematic reviews indicates resolution rates greater than 80% after surgical intervention, particularly when there is complete removal of necrotic tissue, in contrast to conservative treatment, which is predominantly limited to symptomatic control and has a low rate of definitive resolution (KOBAYASHI et al., 2022; HSU et al., 2021; OH; KIM, 2024).

Despite this consensus, it is important to highlight that most of the available evidence derives from retrospective studies and case series, which imposes relevant methodological limitations, such as the absence of randomization and heterogeneity of therapeutic protocols. Still, the consistency of findings across different studies reinforces the superiority of surgical treatment over conservative approaches, especially in more extensive lesions (NISI et al., 2020; OKUYAMA et al., 2020).

Historically, the management of RONJ has been guided by conservative strategies, motivated by the fear of worsening bone necrosis after surgical interventions. However, the evolution of scientific knowledge has shown that such approaches have significant limitations, particularly in moderate and advanced stages, in which disease progression is frequent. This scenario led to the reformulation of clinical guidelines, which began to recognize the benefits of early surgical intervention as a more effective strategy (DE CICCIO et al., 2023; BEDOGNI et al., 2024).

Additionally, studies that address more severe cases of RONJ show that the absence of surgical intervention can favor the progression of the disease to adjacent structures,

including severe complications, such as skull base involvement and systemic infections, reinforcing the importance of a more active approach to the management of the condition (YOSHIZAWA et al., 2019; YAMAGATA et al., 2016). Thus, the current trend points to a paradigm shift, in which surgical treatment is no longer a late option and starts to occupy a central role in the therapy of MRONJ.

3.2 SURGICAL TECHNIQUES EMPLOYED

The surgical techniques used in the management of RONJ vary according to the extent of the lesion and the stage of the disease, and are generally classified into conservative and radical approaches. Among the procedures most described in the literature, sequestrectomy, curettage, and bone resection stand out, with or without safety margins. Evidence indicates that more extensive approaches, which include complete removal of necrotic bone to reach viable tissue, are associated with better clinical outcomes when compared to more conservative techniques (OKUYAMA et al., 2020; NISI et al., 2020).

The achievement of viable and bleeding bone margins is considered one of the main determinants of therapeutic success, since the permanence of necrotic tissue is directly related to disease recurrence (SHIN; KIM, 2018). In this sense, resection with safety margins has been progressively adopted as the preferred strategy in more advanced cases, despite its greater surgical impact.

However, the choice of surgical technique is still the subject of debate in the literature, especially in relation to the ideal extent of resection. While some studies advocate for more aggressive approaches aimed at maximizing the cure rate, others point to the need to preserve anatomical structures and function, particularly in patients with significant comorbidities or systemic impairment (BEDOGNI et al., 2024). This divergence reflects the lack of standardization in surgical protocols and the heterogeneity of the available studies.

In addition, it should be considered that much of the evidence on surgical techniques derives from retrospective studies and case series, which limits the generalization of results and makes it difficult to directly compare different approaches. The variability in the criteria for surgical indication, extent of resection, and use of associated therapies contributes to the lack of consensus in the literature (HSU et al., 2021).

Thus, the choice of surgical approach should be individualized, taking into account factors such as the extent of the lesion, the stage of the MRONJ, the patient's systemic conditions, and the surgeon's experience. The current trend points to a more problem-solving approach, based on the complete removal of necrotic tissue, associated with functional

preservation whenever possible, seeking to balance therapeutic efficacy and surgical morbidity.

3.3 PROGNOSIS AND ASSOCIATED FACTORS

The prognosis of drug-associated osteonecrosis of the jaws (MRONJ) is directly related to the adequacy of the therapeutic approach adopted, being strongly influenced by the extent of the lesion and the complete removal of necrotic tissue. Clinical studies have shown that the persistence of devitalized bone after surgical treatment is associated with higher rates of treatment failure and recurrence, highlighting the importance of a problem-solving surgical approach (OKUYAMA et al., 2020; SHIN; KIM, 2018).

Several studies report success rates of over 80% after surgical intervention, particularly when performed under appropriate planning and execution conditions (KOBAYASHI et al., 2022; HSU et al., 2021). However, these results should be interpreted with caution, since most of the available evidence derives from retrospective studies, with heterogeneity of diagnostic criteria, staging, and therapeutic protocols, which limits comparability between studies and may overestimate positive outcomes.

In addition to the factors related to the surgical technique, the patient's systemic conditions play a relevant role in the prognosis of ONJM. Factors such as chronic inflammation, systemic comorbidities, and compromised immune status have been associated with worse clinical outcomes, which can interfere with healing and favor disease progression (SHIN; KIM, 2018). These aspects reinforce the need for a comprehensive and individualized clinical evaluation in therapeutic planning.

Another relevant point concerns the stage of the disease at the time of diagnosis. Evidence suggests that interventions performed at earlier stages have better results when compared to those performed in advanced stages, in which there is greater bone impairment and risk of complications (DE CICCIO et al., 2023; BEDOGNI et al., 2024). However, this relationship is still influenced by the variability of the staging criteria adopted in the different studies.

Additionally, more severe cases of RONJM, when not adequately treated, can progress to significant complications, including spread of infection and involvement of adjacent structures, which negatively impacts prognosis and may increase patient morbidity (YOSHIZAWA et al., 2019; YAMAGATA et al., 2016). Thus, the prognosis of RONJ does not depend exclusively on surgical intervention, but results from the interaction between local, systemic, and therapeutic factors, requiring a multidimensional and individualized approach.

3.4 MAXILLARY MRONJ AND ASSOCIATED COMPLICATIONS

The occurrence of RONJ in the maxilla presents relevant clinical particularities when compared to the mandible, especially due to its close anatomical relationship with the maxillary sinus, which favors the occurrence of infectious complications, such as maxillary sinusitis. Clinical studies show that the extension of bone necrosis into the maxillary sinus can result in persistent sinusitis, making it difficult to manage the disease and negatively impacting the prognosis (PARK et al., 2020; OTSURU et al., 2022).

In this context, combined therapeutic approaches have been proposed as a strategy to optimize clinical outcomes. The association between oral and maxillofacial surgery to remove necrotic tissue and endoscopic procedures of the paranasal sinuses has shown greater efficacy in resolving infectious conditions, when compared to the isolated approach (PARK et al., 2020). This strategy allows not only the treatment of osteonecrosis, but also the adequate management of associated sinus complications, reducing the persistence of infection.

However, the literature still has limitations regarding the standardization of these combined approaches, since most of the available studies consist of retrospective analyses and case series, with small samples and heterogeneity in the protocols adopted (OTSURO et al., 2022). This limitation makes it difficult to generalize the results and reinforces the need for prospective studies that more robustly evaluate the efficacy of these interventions.

In addition, the approach to JRONJ in the maxilla often requires multidisciplinary action, involving oral and maxillofacial surgeons and otorhinolaryngologists, especially in cases with maxillary sinus involvement. This integration between specialties is essential for the appropriate management of complications and for obtaining better clinical outcomes.

Thus, although the association between maxillary RONJ and sinusitis represents an additional therapeutic challenge, current evidence suggests that integrated and more aggressive approaches can contribute significantly to the resolution of the disease. However, the absence of standardized protocols and the methodological limitations of the available studies indicate the need for greater scientific production in this area, with a view to consolidating better established guidelines for the management of these complications.

3.5 ADJUNCTIVE THERAPIES IN SURGICAL TREATMENT

The use of adjuvant therapies in the treatment of JRONJ has been widely investigated with the aim of enhancing the results obtained with surgical intervention, especially with regard to tissue healing and the reduction of postoperative complications. Among these approaches, the use of autologous platelet concentrates, such as platelet- and leukocytes-

rich fibrin (L-PRF), stands out, which has shown positive effects on bone regeneration and modulation of the local inflammatory response (ÖZALP et al., 2021; RICOTTA et al., 2021).

The available studies suggest that the application of L-PRF in surgical sites promotes gradual release of growth factors, contributing to angiogenesis and acceleration of the tissue repair process. However, despite the promising results, the evidence is still limited by small sample sizes and the absence of randomized controlled trials, which makes it difficult to standardize this approach and compare between different protocols (ÖZALP et al., 2021).

In addition to platelet concentrates, other adjuvant therapies, such as photobiomodulation (low-level laser), have been explored in an attempt to improve clinical outcomes. Although some studies point to benefits related to pain reduction and healing stimulation, there is still no consensus in the literature regarding its efficacy and clinical indication, due to the heterogeneity of the parameters used and the low methodological quality of the available studies (OH; KIM, 2024).

Additionally, the use of biomaterials and topical agents has been investigated as an alternative to optimize bone regeneration and reduce the risk of infection. However, as observed with other adjuvant therapies, the absence of standardized protocols and the scarcity of high-level studies limit their routine incorporation into clinical practice.

Thus, although adjuvant therapies represent a promising strategy in the management of RONJM, their use should be considered complementary to surgical treatment, not a substitute. Current evidence suggests that the best clinical outcomes are obtained when these approaches are coupled with complete removal of necrotic tissue, reinforcing the central role of surgery in treating the disease. Still, there is a need for prospective and controlled studies that allow the establishment of more consistent protocols based on robust evidence.

3.6 GUIDELINES AND CURRENT TRENDS IN THE MANAGEMENT OF MRONJ

Current clinical guidelines for the management of drug-associated osteonecrosis of the jaws (MRONJ) reflect a significant shift in the therapeutic paradigm observed in recent decades. Initially, the recommendations prioritized conservative approaches, focusing on symptom control and preventing disease progression. However, with the accumulation of scientific evidence, especially from clinical studies and systematic reviews, the superiority of surgical treatment in various clinical scenarios has come to be recognized (DE CICCIO et al., 2023; BEDOGNI et al., 2024).

The update of the guidelines of the American Association of Oral and Maxillofacial Surgeons (AAOMS), as well as European societies, evidences this transition, by

incorporating the indication of early surgical intervention as a valid therapeutic strategy, especially in cases with greater extent of bone necrosis. This change is directly related to the more favorable outcomes observed in patients undergoing complete necrotic tissue removal, compared to those treated exclusively by conservative methods (D.E. CICCIO et al., 2023).

However, despite this advance, there are still divergences between different international guidelines, particularly with regard to the ideal timing of surgical intervention and the extent of the procedure. While some recommendations suggest a more aggressive and earlier approach, others still indicate caution, especially in patients at high systemic risk, reflecting the absence of absolute consensus in the literature (BEDOGNI et al., 2024).

In addition, the critical analysis of the guidelines reveals that many of the recommendations are based on low- to moderate-level evidence, predominantly derived from observational studies, which limits the robustness of the conclusions and reinforces the need for controlled clinical trials. This limitation highlights one of the main challenges in the management of RONJM, which is the scarcity of high-quality evidence capable of definitively guiding clinical practice.

In this context, there is a contemporary trend towards individualization of treatment, in which the therapeutic choice is based not only on the stage of the disease, but also on the patient's systemic conditions, the extent of the lesion, and the professional's experience. This personalized approach seeks to balance treatment efficacy with minimizing surgical morbidity, reflecting a more patient-centered clinical practice.

Thus, current guidelines point to a more dynamic and evidence-based approach, in which surgical treatment plays a central role in the management of RONJM. However, the heterogeneity of the available studies and the lack of standardization reinforce the need for greater scientific production, especially prospective and randomized studies, which allow the consolidation of more consistent and widely accepted therapeutic protocols.

4 CONCLUSION

It is concluded that the surgical management of osteonecrosis of the jaws associated with drugs is the most effective therapeutic approach, especially in advanced stages of the disease, with higher resolution rates when compared to conservative treatment. The complete removal of necrotic tissue is a determining factor for clinical success, and can be enhanced by the use of adjuvant therapies. In addition, there is a current trend towards early indication of surgical intervention, although there are still gaps in the literature regarding the standardization of protocols, reinforcing the need for studies with a higher level of evidence.

REFERENCES

- Bedogni, A., et al. (2024). Italian position paper (SIPMO/SICMF) on medication-related osteonecrosis of the jaw (MRONJ). *Journal of Bone Oncology*.
- De Cicco, D., et al. (2023). Medication-related osteonecrosis of the jaws: A comparison of SICMF–SIPMO and AAOMS guidelines. *Diagnostics*, 13(13), 2137.
- Hsu, K. J., et al. (2021). Investigation of the effectiveness of surgical treatment on medication-related osteonecrosis of the jaw: A systematic review. *Journal of Clinical Medicine*.
- Kobayashi, E., et al. (2022). Prognosis of medication-related osteonecrosis of the jaw with surgical treatment. *Journal of Oral and Maxillofacial Surgery*.
- Nisi, M., et al. (2020). Surgical management of medication-related osteonecrosis of the jaw related to dental implants. *Clinical Oral Implants Research*.
- Okuyama, K., et al. (2020). Surgical strategy for medication-related osteonecrosis of the jaw in the maxilla. *Journal of Oral and Maxillofacial Surgery*.
- Otsuru, M., et al. (2022). Retrospective analysis of treatment outcomes of maxillary sinusitis associated with medication-related osteonecrosis of the jaw. *Journal of Oral and Maxillofacial Surgery*.
- Park, J., et al. (2020). Medication-related osteonecrosis of the maxilla: Surgical management combined with endoscopic sinus surgery. *Journal of Craniofacial Surgery*.
- Ricotta, F., et al. (2021). The use of platelet-rich plasma in the management of medication-related osteonecrosis of the jaw. *Minerva Stomatologica*.
- Shin, W., & Kim, C. H. (2018). Prognostic factors for outcome of surgical treatment in medication-related osteonecrosis of the jaw. *Journal of Cranio-Maxillofacial Surgery*.
- Özalp, Ö., et al. (2021). Promising results of surgical management of advanced medication-related osteonecrosis of the jaw with L-PRF application. *Journal of Stomatology, Oral and Maxillofacial Surgery*.
- Oh, S., & Kim, Y. (2024). Medication-related osteonecrosis of the jaw: A rapid review of treatment strategies. *Journal of Oral Medicine*.
- Kim, J., et al. (2025). Medication-related osteonecrosis of the jaw: An evidence-based position statement. *Journal of Bone Metabolism*.
- Yoshizawa, Y., et al. (2019). Advanced medication-related osteonecrosis of the jaw with cranial base involvement: Report of cases. *Journal of Oral and Maxillofacial Surgery*.
- Yamagata, K., et al. (2016). Brain abscess caused by medication-related osteonecrosis of the jaw: Case report. *Journal of Oral and Maxillofacial Surgery*.
- Altay, M., et al. (2018). Medication-related osteonecrosis of the jaw: An institutional experience. *Journal of Oral and Maxillofacial Surgery*.

COMPONENTS AND PHYSIOLOGY OF PERIODONTAL STRUCTURES

COMPONENTES E FISIOLÓGIA DAS ESTRUTURAS PERIODONTAIS

COMPONENTES Y FISIOLÓGÍA DE LAS ESTRUCTURAS PERIODONTALES



<https://doi.org/10.56238/sevened2026.021-003>

Isabella Santos Paula¹, Maria Clara de Paula Lima², Fernanda Castelo Branco Santos Bettero³, Ana Paula de Lima Oliveira⁴, Guilherme José Lopes de Oliveira⁵, Priscilla Barbosa Ferreira Soares⁶

ABSTRACT

Introduction: The periodontium is a dynamic tissue complex, essential for the protection and support of dental elements, whose histophysiological understanding has significantly evolved with advances in mechanobiology.

Objective: The aim of this study was to conduct a narrative literature review on the anatomy and physiology of the periodontium, integrating classical concepts with recent scientific updates.

Materials and Methods: An electronic search was performed in the PubMed/MEDLINE database including publications from 2014 to February 22, 2026. A total of 67 articles were included, organized into four thematic axes: (1) periodontal ligament and mechanobiology; (2) junctional epithelium; (3) gingival crevicular fluid; and (4) alveolar bone remodeling. Additionally, classical textbooks of Periodontology and Oral Histology were consulted to support the anatomical and histological aspects of periodontal structures, serving as complementary theoretical support to recent scientific evidence.

Results: The studies showed that the interaction among cellular components, extracellular matrix, and vascular supply provides the periodontal complex with a high adaptive and reparative capacity. Thus, the functional balance between protective and attachment tissues proved to be essential for maintaining periodontal health stability.

Conclusion: The integration of classical literature and contemporary reviews allowed the development of an updated approach, grounded in established biological principles, which is essential for dental practice, enabling more accurate diagnoses and more predictable regenerative therapies.

¹ Faculdade de Odontologia, Universidade Federal de Uberlândia. E-mail: isabellasantospaula@gmail.com

² Faculdade de Odontologia, Universidade Federal de Uberlândia. E-mail: mariaclarapaula@hotmail.com

³ Faculdade de Odontologia, Universidade Federal de Uberlândia. E-mail: fcb1506@hotmail.com

⁴ Faculdade de Odontologia, Universidade Federal de Uberlândia. E-mail: aploliveira@ufu.br

⁵ Faculdade de Odontologia, Universidade Federal de Uberlândia. E-mail: guilherme.lopesoliveira@ufu.br

⁶ Faculdade de Odontologia, Universidade Federal de Uberlândia

Keywords: Periodontium. Mechanobiology. Oral Histology. Periodontal Homeostasis. Tissue-microbiota Interaction.

RESUMO

Introdução: O periodonto é um complexo tecidual dinâmico, essencial para a proteção e sustentação dos elementos dentários, cuja compreensão histofisiológica evoluiu significativamente com os avanços da mecanobiologia.

Objetivo: O objetivo deste estudo foi realizar uma revisão narrativa da literatura sobre a anatomia e a fisiologia do periodonto, integrando conceitos clássicos às atualizações científicas recentes.

Materiais e Métodos: Foi realizada uma busca eletrônica na base de dados PubMed/MEDLINE com publicações de 2014 até 22 de fevereiro de 2026. Foram incluídos 67 artigos, em quatro eixos temáticos: (1) ligamento periodontal e mecanobiologia; (2) epitélio juncional; (3) fluido gengival crevicular; e (4) remodelação óssea alveolar. Adicionalmente, foram consultadas obras clássicas da Periodontia e Histologia Oral para fundamentação dos aspectos anatômicos e histológicos das estruturas periodontais, sendo utilizadas como suporte teórico complementar às evidências científicas recentes.

Resultados: Os estudos mostraram que a interação entre componentes celulares, matriz extracelular e suprimento vascular conferem ao complexo periodontal elevada capacidade adaptativa e reparadora. Assim, o equilíbrio funcional entre tecidos de proteção e de inserção mostrou-se essencial para a estabilidade da saúde periodontal.

Conclusão: A integração entre literatura clássica e revisões contemporâneas permitiu a construção de uma abordagem atualizada, ancorada em fundamentos biológicos estabelecidos, indispensável para a prática odontológica, para diagnósticos mais precisos e terapias regenerativas com maior previsibilidade de sucesso.

Palavras-chave: Periodonto. Mecanobiologia. Histologia Oral. Homeostase Periodontal. Interação Tecido-microbiota.

RESUMEN

Introducción: El periodonto es un complejo tisular dinámico, esencial para la protección y el soporte de los elementos dentarios, cuyo entendimiento histofisiológico ha evolucionado significativamente con los avances de la mecanobiología.

Objetivo: El objetivo de este estudio fue realizar una revisión narrativa de la literatura sobre la anatomía y fisiología del periodonto, integrando conceptos clásicos con actualizaciones científicas recientes.

Materiales y Métodos: Se realizó una búsqueda electrónica en la base de datos PubMed/MEDLINE con publicaciones desde 2014 hasta el 22 de febrero de 2026. Se incluyeron 67 artículos, organizados en cuatro ejes temáticos: (1) ligamento periodontal y mecanobiología; (2) epitelio de unión; (3) fluido crevicular gingival; y (4) remodelación ósea alveolar. Además, se consultaron obras clásicas de Periodoncia e Histología Oral para fundamentar los aspectos anatómicos e histológicos de las estructuras periodontales, utilizándose como soporte teórico complementario a la evidencia científica reciente.

Resultados: Los estudios demostraron que la interacción entre los componentes celulares, la matriz extracelular y el suministro vascular confiere al complejo periodontal una elevada

capacidad adaptativa y reparadora. Así, el equilibrio funcional entre los tejidos de protección y de inserción resultó ser esencial para la estabilidad de la salud periodontal.

Conclusión: La integración entre la literatura clásica y las revisiones contemporáneas permitió construir un enfoque actualizado, basado en fundamentos biológicos establecidos, indispensable para la práctica odontológica, favoreciendo diagnósticos más precisos y terapias regenerativas con mayor previsibilidad de éxito.

Palabras clave: Periodonto. Mecanobiología. Histología Oral. Homeostasis Periodontal. Interacción Tejido-microbiota.

1 INTRODUCTION

The periodontium corresponds to the set of structures that surround and support the tooth, constituting the insertion complex responsible for maintaining the functional integrity of the dental element. It is made up of hard and soft tissues organized in an integrated manner, whose main function is to provide mechanical support, absorb and properly distribute the forces generated during chewing (Newman *et al.*, 2020; Berglundh *et al.*, 2024).

From a structural and functional perspective, the periodontal organ is a highly specialized and biologically integrated unit, composed of four interdependent components: (1) the gum, which covers and protects the underlying structures; (2) the periodontal ligament, a specialized connective tissue that connects the cementum to the alveolar bone, and acts as a cushioning system for occlusal loads; (3) cementum, avascular mineralized connective tissue that covers the root surface, and allows the insertion of periodontal fibers; and (4) the alveolar bone, responsible for inserting and supporting the tooth in the dental arch (Newman *et al.*, 2020; Berglundh *et al.*, 2024)

The periodontal ligament plays a central role in this system, not only as a mechanical support element, but as a highly mechanosensitive tissue, capable of converting physical stimuli into cellular and molecular responses, which regulate bone remodeling and the maintenance of periodontal homeostasis through mechanotransduction and intracellular signaling mechanisms (Wen *et al.*, 2025).

Although there are numerous studies addressing isolated components of the periodontium, there is a relative scarcity of publications that integrate the classical anatomical and histological foundations with contemporary scientific evidence in a didactic way. In this context, this chapter aims to consolidate and update the knowledge about gingiva, periodontal ligament, cementum, and alveolar bone, presenting the periodontium as a dynamic functional unit.

2 METHODOLOGY

This chapter was prepared by a structured narrative review of the literature, associated with the consultation of consolidated classical works in the area of Periodontics and Oral Histology, used to support the anatomical and histological aspects of periodontal structures.

For scientific updating, an electronic search was performed in the PubMed/MEDLINE database until February 22, 2026, with delimitation of publications from 2014 and application of the "Review" and "Systematic Review" filters. The strategy was organized into four thematic axes: (1) periodontal ligament and mechanobiology; (2) junctional epithelium; (3) crevicular gingival fluid; and (4) alveolar bone remodeling.

A total of 67 studies were identified, consolidated and screened by reading titles and abstracts. Reviews with a predominantly clinical-therapeutic focus, specific orthodontic applications, regenerative biomaterials, surgical techniques, adjuvant interventions, and exclusively methodological or systemic approaches with no direct relationship with periodontal physiology were excluded. Reviews that addressed structural, cellular, and molecular aspects related to the functional dynamics of the periodontal ligament, junctional epithelium, crevicular gingival fluid, and alveolar bone remained included.

The integration between classic literature and contemporary reviews allowed the construction of an updated approach, anchored in established biological foundations.

3 LITERATURE REVIEW

3.1 GENGIVA - MACROSCOPIC ASPECT

Figure 1



The gingiva constitutes the portion of the oral mucosa that covers the alveolar processes and surrounds the neck of the teeth, playing an essential role in protecting the underlying periodontal tissues against masticatory trauma and local irritants, such as bacterial biofilm (Newman *et al.*, 2020; Berglundh *et al.*, 2024). From a clinical point of view, gingival health is characterized by the absence of inflammatory signs, such as bleeding on probing, erythema, and edema, and can be present in both an intact and reduced periodontium, as long as tissue stability is maintained (Chapple *et al.*, 2018).

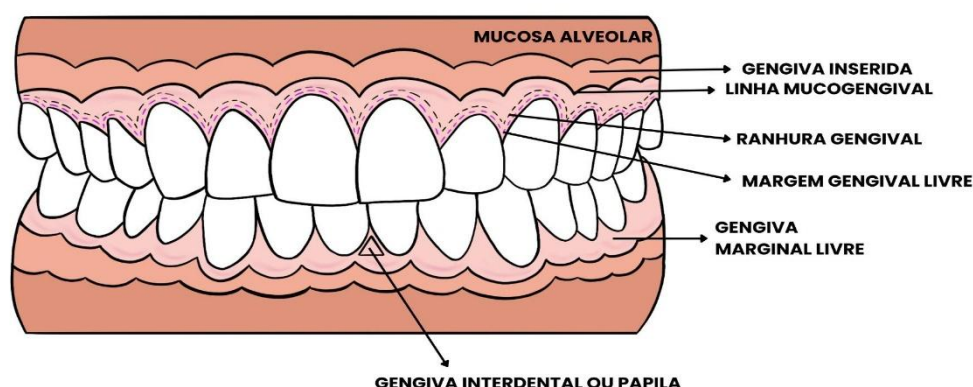
From an anatomical point of view, it is divided into **marginal (or free) gingiva and inserted gingiva (Figures 2, 3 and 4)**. Although these regions present differences in thickness, degree of keratinization, and histological characteristics, they are all structurally

organized to act as an efficient barrier against mechanical aggression and the penetration of microorganisms into the deeper periodontal tissues (Newman *et al.*, 2020).

The **marginal gum**, also called free gum, corresponds to the coronary portion of the gum that surrounds the tooth in the form of a necklace. In approximately 50% of cases, the gingiva inserted can be delimited by a discrete linear depression called the free gingival groove. This gingival strip measures, on average, about 1 mm in width and constitutes the outer wall of the gingival sulcus. It can be removed from the tooth surface by carefully inserting a periodontal probe. The most apical point of the concave curvature of the marginal gingiva is called the gingival zenith, as described in the classic literature on Periodontics (Newman *et al.*, 2020).

Figure 2

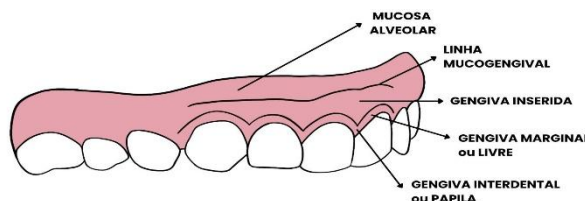
Illustration of the alveolar mucosa; inserted gingiva; mucogingival line; gingival groove; free gingival margin; free marginal gingiva; interdental gingiva or papilla



Source: Illustrated by the authors. Adapted from Lindhe's Treatise on Clinical Periodontics and Oral Implantology. 6. ed. 2018, page 35, figure 1.10.

Figure 3

Anatomical components of the gum

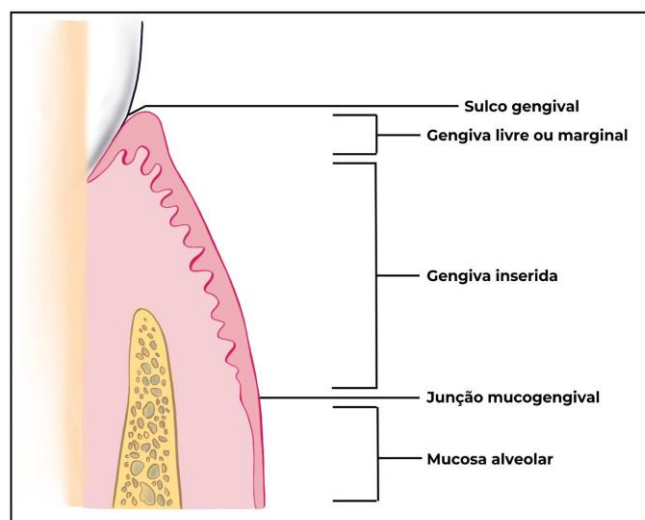


Source: Illustrated by the authors. Adapted from Lindhe's Treatise on Clinical Periodontics and Oral Implantology. 7. ed. Rio de Janeiro: Guanabara Koogan, 2024, page 5, figure 1.5.

The **inserted gingiva** corresponds to the portion of the gingiva firmly adhered to the periosteum of the underlying alveolar bone, presenting a firm and resilient consistency. It extends from the marginal gingiva to the mucogingival junction, which is an important clinical reference. Unlike the alveolar mucosa, the inserted gingiva is keratinized and exerts a protective function against masticatory forces (Newman *et al.*, 2020; Nanci, 2019).

Figure 4

Anatomical components of the gum



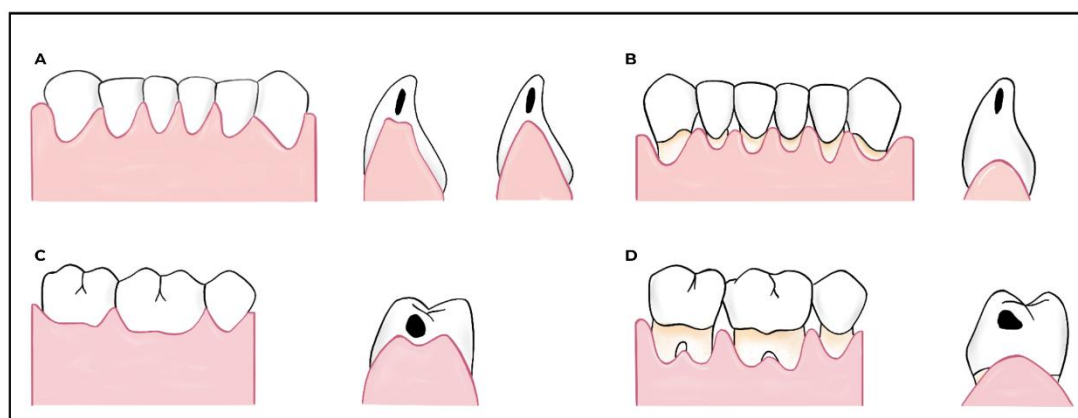
Source: Illustrated by the authors. Adapted from NEWMAN, Michel G. Newman and Carranza - Clinical Periodontics 13th ed. 2020, page 21, figure 3.2.

The **interdental papilla** occupies the interproximal space located below the area of contact between adjacent teeth, called the gingival niche. It can have a pyramidal or "col" shape, the latter characterized by a depression that connects the buccal and lingual papillae. Its morphology depends on the presence or absence of the contact point, the distance between the contact point and the alveolar bone crest, and the occurrence of gingival

recession. (Newman *et al.*, 2020; Berglundh *et al.*, 2024). In the anterior region, the shape is pyramidal, in which the tip of the papilla is immediately below the point of contact. In the posterior region, the "col" shape is a valley-shaped depression that connects the lingual papilla with the buccal papilla and adapts to the shape of the interproximal contact of the posterior teeth (Figure 5).

Figure 5

Diagram of comparisons of anatomical variations of interdental col in normal gingiva and gingival retraction



Source: Illustrated by the authors. Adapted from NEWMAN, Michael G. Newman and Carranza - Clinical Periodontics. 13th. ed. Rio de Janeiro: GEN Guanabara Koogan, 2020, page 22, figure 3.6.

3.2 GENGIVA - MICROSCOPIC APPEARANCE

Figure 6



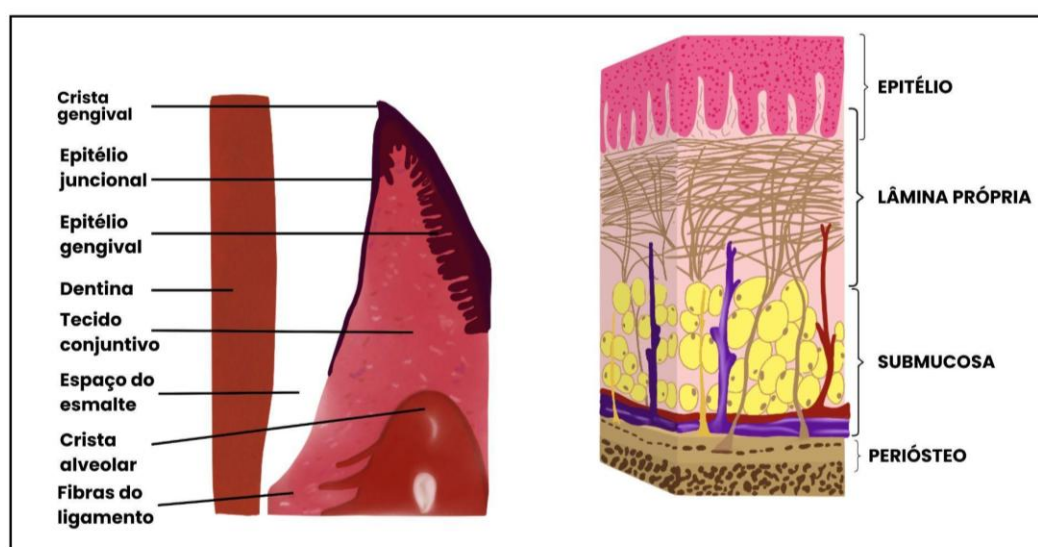
Microscopically, the gingiva is composed of stratified squamous epithelium that covers a core of underlying connective tissue. The epithelium is cellularly predominant, with little extracellular matrix and absence of blood vessels, while the connective tissue is vascularized,

consisting mainly of type 1 collagen fibers, produced by fibroblasts and immersed in an extracellular matrix. The interaction between these components ensures mechanical resistance and protection of periodontal tissues (Nanci, 2019).

The oral epithelium is a stratified squamous epithelium that lines the surface of the oral mucosa and constitutes the main protective barrier between the oral environment and the underlying connective tissues (Figure 5). Histologically, it is organized into well-defined cell layers, supported by intense intercellular cohesion by means of desmosomes and intermediate cyokeratin filaments. Its integrity is maintained by a continuous process of cell renewal, in which progenitor cells located in the basal layer — including stem cells and transient amplifying cells — undergo mitotic divisions and originate keratinocytes that migrate towards the surface, undergoing terminal differentiation and subsequent desquamation (Nanci, 2019).

Figure 7

Components of the oral epithelium.



Source: Illustrated by the authors. Adapted from Ten Cate - Oral Histology. 9. ed. 2019, page 283, figure 12-33.

Depending on the region of the oral cavity, this maturation process can follow two main patterns: keratinization, typical of the masticatory mucosa, and non-keratinization, characteristic of the lining mucosa. In the keratinized epithelium, the basal, spinous, granulosa and corneal layers are distinguished, with the formation of the cornified cell envelope rich in keratins and structural proteins, conferring greater mechanical resistance and impermeability. In the non-keratinized epithelium, the basal and spinous layers are followed by the intermediate and superficial layers, without evident formation of a granulosum

stratum or anucleated layer, maintaining nucleated superficial cells and greater tissue flexibility (Nanci, 2019).

In this anatomical niche is the crevicular gingival fluid (CGF), also called gingival crevicular fluid. In health conditions, it is described as a modified transudate derived from the vascular plexus of gingival connective tissue, which migrates into the gingival sulcus and participates in local homeostasis (Newman *et al.*, 2020; Berglundh *et al.*, 2024). It plays a relevant role in immune defense, including the physiological migration of neutrophils to the gingival cleft (Newman *et al.*, 2020; Berglundh *et al.*, 2024).

From a functional point of view, FGC promotes mechanical sulcus cleaning, leukocyte transport, immunoglobulins (IgG, IgA), complement system components, and enzymes such as matrix metalloproteinases, reflecting both the immune response and tissue destructive activity. Thus, in addition to actively participating in local defense, the FGC stands out as a non-invasive diagnostic tool capable of identifying inflammatory biomarkers and bone resorption even before the evident clinical manifestation, reinforcing its relevance in contemporary periodontal practice (Barros *et al.*, 2016). Recent revisions reinforce the potential of FGC as a minimally invasive diagnostic tool for monitoring periodontal activity (Fatima *et al.*, 2021; Ghallab, 2018).

The **gingival sulcus** is defined as a shallow cleft around the tooth, bounded internally by the tooth surface and externally by the sulcular epithelium, which lines the inner surface of the free marginal gingiva. It has a "V" shape, allowing the insertion of the periodontal probe for diagnostic purposes (Newman *et al.*, 2020). The evaluation of the depth of the sulcus is a fundamental clinical parameter in periodontal analysis.

The clinical measurement of this depth is carried out by means of periodontal probing, a procedure in which the distance reached by the probe, when inserted inside the sulcus, is estimated, accounted for in millimeters, from the gingival margin, to the bottom of the gingival sulcus. However, the depth of probing can be influenced by factors such as the diameter of the instrument, the force applied, and the degree of tissue inflammation.

The junctional epithelium (EJ) is described as a highly dynamic, non-keratinized epithelial barrier characterized by intense proliferative activity, functional permeability, and firm adhesion to the tooth surface. Their cells undergo continuous desquamation, contributing to the mechanical removal of microorganisms and to the control of bacterial invasion at the dentogingival interface (Nanci, 2019; Schroeder & Listgarten, 2003; Yuan *et al.*, 2021).

Structurally, the EJ is continuous with the adjacent keratinized oral epithelium (EO), and presents a specialized interface, composed of hemidesmosomes and a basal lamina, which ensure its attachment to the tooth. Underlying this interface is a zone of connective

tissue rich in collagen fibers, with organized marginal bone and a delicate vascular network, composing the periodontal support apparatus (Nanci, 2019; Schroeder & Listgarten, 2003). Morphologically, it is organized as an epithelial collar around the cervical portion of the tooth, delimiting the bottom of the gingival sulcus; it is thicker in the coronary region and progressively thins in an apical direction along the tooth surface. Its constant renewal results from the active proliferation of basal keratinocytes, which favors rapid repair and maintenance of the integrity of the tooth-gum interface.

From a structural point of view, EJ is distinguished by having intercellular junctions including desmosomes, adherent junctions and gap junctions, as well as wide intercellular spaces. This organization allows the controlled passage of gingival crevicular fluid and the migration of inflammatory cells towards the sulcus, composing a dynamic defense mechanism (Theodoro *et al.*, 2023). The integrity of these junctions depends on the organization of specific proteins, such as claudins and other adhesion proteins, which regulate epithelial permeability and contribute to the maintenance of biological sealing. At the same time, adhesion to the mineralized surface of the tooth is mediated by hemidesmosomes and an internal basal lamina, ensuring firm anchorage and effective biological sealing (Nanci, 2019; Schroeder & Listgarten, 2003; Theodoro *et al.*, 2023). This seal is not static, but results from a dynamic balance between cell adhesion, epithelial renewal, and local immune control (Nanci, 2019).

Functionally, EJ occupies a strategic position between hard tissue and soft tissue, acting as the first line of defense against bacterial invasion and contributing to periodontal homeostasis. the junctional epithelium should be understood as a dynamic, immunologically active structure that is essential for maintaining periodontal health (Newman *et al.*, 2020; Theodoro *et al.*, 2023). In addition to acting as a physical barrier, the junctional epithelium actively participates in the innate immune response, through the expression of inflammatory mediators and signaling molecules that modulate the recruitment of neutrophils to the gingival sulcus (Yuan *et al.*, 2021).

The underlying connective tissue, in turn, has its own characteristics, including the physiological presence of a discrete inflammatory infiltrate, in addition to abundant collagen fibers, fibroblasts, blood vessels, nerves, and extracellular matrix, composing the connective insertion that structurally supports the dentogingival complex. The fibers of the gingival connective tissue are fundamental components of the gums and play an essential role in its resistance, support, and functional adaptation. This tissue is rich in fibers produced mainly by fibroblasts, with collagen fibers being the most abundant and important. They are predominantly formed by type I collagen, with a lower amount of type III collagen, and provide

great tensile strength, allowing the gum to withstand the mechanical forces of chewing and remain firmly adhered to the dental and bone structures. In addition, these collagen fibers are organized into bundles that directly contribute to the stability of the gums around the teeth.

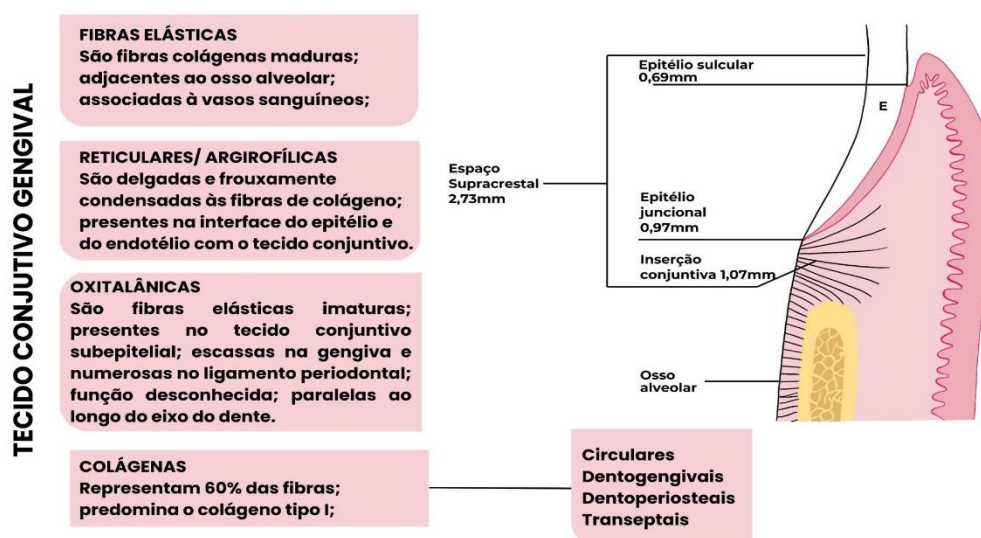
Although in smaller quantities, elastic fibers are also present, which include elastic fibers themselves, in addition to elauninic and oxythalanic fibers. These fibers are responsible for giving a certain elasticity to the gum tissue, allowing it to have a slight ability to adapt without losing its structural integrity. Even though they are discreet in the gums, they play an important complementary role.

Another type of fiber found is the reticular fibers, which are mainly made up of type III collagen. These fibers are thinner and form a delicate network that supports the cells and blood vessels present in the connective tissue. They contribute to the internal organization of the tissue, offering more subtle structural support compared to collagen fibers.

Thus, the gingival connective tissue has a predominance of collagen fibers, responsible for resistance and firmness, associated with elastic and reticular fibers that help with elasticity and internal support, ensuring the integrity and proper functioning of the gums.

Figure 8

Representation of elastic fibers; reticular fibers; oxytalan fibers; and collagen fibers - constitution of gingival connective tissue



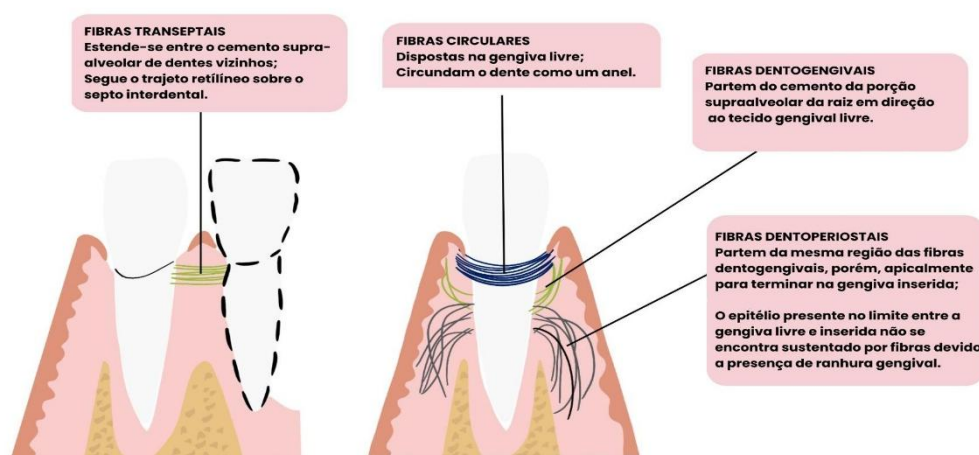
Source: Illustrated by the authors. Adapted from LINDHE *et al.* 2024, - Treaty on Clinical Periodontics and Oral Implantology - 7th ed. , page 7, figure 2.4.

The fibers present are mainly collagen fibers of the gingival connective tissue, organized in groups that help maintain the integrity and position of the gums around the teeth. The main types of fibers of the protective periodontium are: (1) Dentogengival fibers, which extend from the cementum of the tooth to the gums with the function of keeping the gums

adhered to the tooth; (2) Circular fibers surround the tooth like a "ring" with the function of keeping the gums firm around the tooth; (3) Dentoperiosteal fibers leave the cementum crossing the bone to the periosteum with the function of structural reinforcement of the gum; (4) Transeptal fibers extend from one tooth to the other (cementum to cementum) with the function of maintaining tooth alignment.

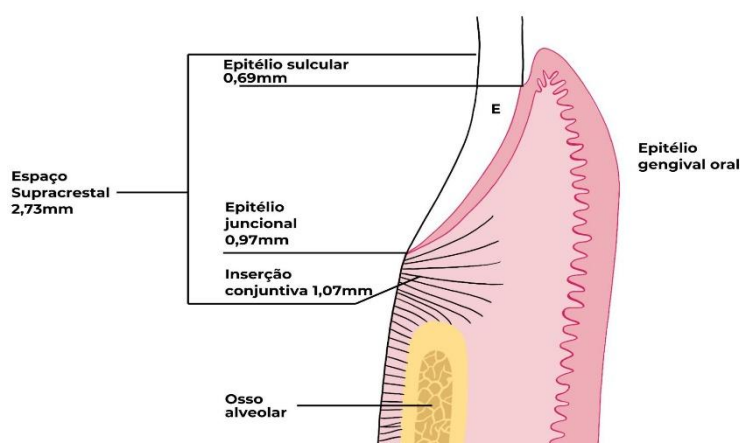
Figure 9

Representation of transeptal fibers; circular fibers; dentogingival fibers; and dentoperiosteal fibers



Source: Illustrated by the authors. Adapted from LINDHE *et al.* 2024, - Treaty on Clinical Periodontics and Oral Implantology - 7th ed. , page 16, figure 1.6.

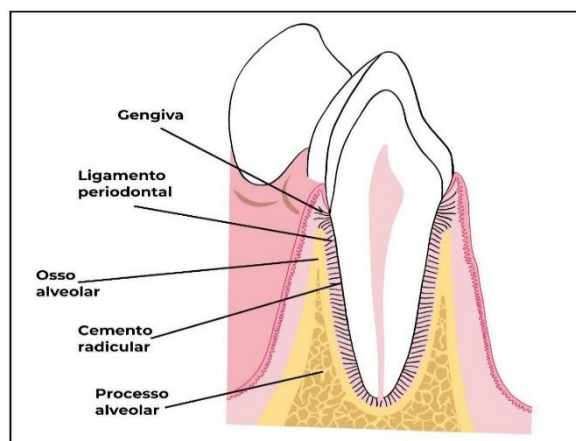
The supracrestal insertion space - formerly called biological space - corresponds to the dimension composed of the junctional epithelium and the supracretal conjunctive insertion, totaling approximately 2 mm, as described in classical histometric studies (Gargiulo *et al.*, 1961) and conceptually redefined in the 2018 World Workshop (Caton *et al.*, 2018). Its integrity is essential for all gingival tissues to remain attached to the tooth, preventing periodontal changes, so it acts as a defense area of the body and must be respected in dental rehabilitation procedures (Caton *et al.*, 2018; Lyra *et al.*, 2022; Bertolini *et al.*, 2024).

Figure 10*Dentogingival unit*

Source: Illustrated by the authors. Adapted from LINDHE *et al.* 2024, - Treaty on Clinical Periodontics and Oral Implantology - 7th ed. , page 9, figure 1.15.

3.3 PERIODONTAL LIGAMENT

The periodontal ligament is a loose, highly vascularized connective tissue with a large number of cells, which surrounds the tooth roots and promotes the union between the root cementum and the lamina dura, that is, the alveolar bone itself. In addition to its structural function, the periodontal ligament is considered a biologically active tissue, capable of responding adaptively to mechanical and inflammatory stimuli (Berglundh *et al.*, 2024; Zhao *et al.*, 2025). Towards the coronal portion, it maintains continuity with the lamina propria of the gingiva, being delimited by bundles of collagen fibers that extend from the crest of the alveolar bone to the root of the tooth, known as alveolar crest fibers (Berglundh *et al.*, 2024).

Figure 11*Anatomy of the components of the periodontium*

Source: Illustrated by the authors. Adapted from LINDHE *et al.* 2024, - Treaty on Clinical Periodontics and Oral Implantology - 7th ed., chapter 3, page 2, figure 1.1.

The periodontal ligament is assigned several functions, which can be grouped into four main categories:

1. It performs the physical function by anchoring the tooth, promoting a firm union between the cementum and the alveolar bone;
2. Ensures mechanical stability and acts as a shock absorber capable of protecting both the tooth and the alveolar bone against the impacts of intense forces generated during chewing;
3. It also performs a formative and modeling function, functioning as an essential cellular reservoir for the maintenance of tissue homeostasis, as well as for the repair and regeneration of cellular components and collagen fibers;
4. It has a nutritional function, as it ensures the blood and nutrient supply to cementum, alveolar bone and the periodontal ligament itself, while contributing to the removal of metabolites;
5. It has a sensory function, since its rich innervation allows, through specific receptors, the perception of forces of different intensities applied to the teeth (Newman *et al.*, 2020; Berglundh *et al.*, 2024; Nanci, 2019).

Thus, the periodontal ligament should be understood as a dynamic tissue, which integrates mechanical, biological, and sensory functions in a coordinated manner (Newman *et al.*, 2020).

Its average thickness is about 0.2 mm, and may vary according to the species, the age of the individual, the distance from the JCE and the functional demands. The existence of the periodontal ligament allows the forces generated during mastication and other occlusal contacts to be distributed and absorbed by the alveolar process, through the alveolar bone itself. In addition, it plays a fundamental role in tooth mobility, which largely depends on the width and height of this ligament (Berglundh *et al.*, 2024).

The periodontal ligament is made up of several cell types and a specialized extracellular matrix. Among the cells present, fibroblasts stand out, which are the most numerous and are arranged parallel to the main collagen fibers, being responsible for both the synthesis and degradation of collagen, which ensures constant tissue renewal. Also present are cementoblasts, located on the surface of the root cementum adjacent to the periodontal ligament space, where they act in the formation of cementum, and osteoblasts, located on the surface of the alveolar bone facing the periodontal space, playing a fundamental role in bone formation. In addition, there are osteoclasts, responsible for bone resorption, and odontoclasts, related to the resorption of dental tissues (Berglundh *et al.*, 2024).

The periodontal ligament also contains histiocytes and different defense cells, such as neutrophils, macrophages, eosinophils, and mast cells, which participate in inflammatory and immune responses. Cells associated with neurovascular elements are also present, as well as nerve fibers and blood vessels, which contribute to the sensory and nutritional functions of the tissue (Newman *et al.*, 2020).

This tissue is in a permanent process of renewal, in which aged cells and fibers are continuously degraded and replaced by new structures. Mitotic activity is often observed, especially in fibroblasts and endothelial cells. Fibroblasts are responsible for the production of collagen fibers, while remaining mesenchymal cells can differentiate into osteoblasts and cementoblasts. The speed at which the formation and differentiation of osteoblasts, cementoblasts, and fibroblasts occurs directly influences collagen production, as well as cementum and bone formation (Newman *et al.*, 2020). Recent studies demonstrate that this continuous renewal process involves regulated mechanisms of cell proliferation and programmed cell death, essential for the maintenance of periodontal tissue homeostasis (He *et al.*, 2023).

In addition to the cellular elements, the periodontal ligament has an extracellular matrix that fills the spaces between fibers and cells. It is presumed to consist largely of solvation water and the rest corresponds to the fundamental components (fibronectin, proteoglycans, structural glycoproteins, electrolytes, hormones, laminin and mineral salts). Its function would be mainly nutritious. This tissue also has a neural network and an extensive blood supply (de Jong *et al.*, 2017; Newman *et al.*, 2020). The organized arrangement of these groups of fibers allows the periodontal ligament to distribute occlusal forces efficiently to the alveolar bone (Nanci, 2019).

In the periodontal ligament, the predominant types of collagen are types I, III, and XII. Most collagen fibrils are organized into well-defined bundles, which resemble braided cords. Although the individual fibrils undergo constant remodeling, the bundle as a whole maintains its structure and function, which allows the ligament to continuously adapt to the forces and mechanical stresses to which it is subjected (Nanci, 2019).

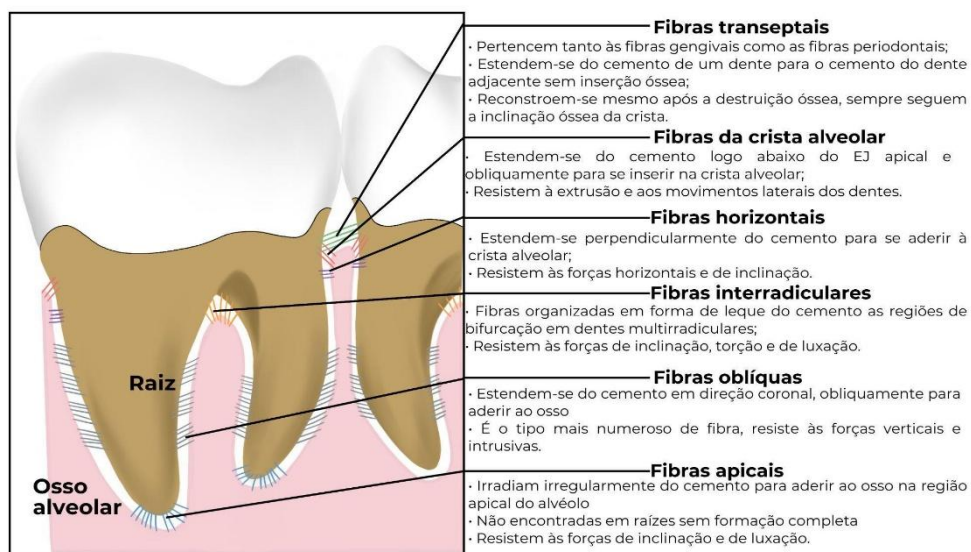
The bundles that extend between the root cementum and the alveolar bone constitute the main groups of fibers of the periodontal ligament. Among them, the alveolar crest group stands out, which attaches to the cementum just below the cementocementary junction and runs in an inferior and lateral direction to insert itself into the crest of the alveolar bone. Just below this group is the horizontal group, whose fibers are arranged perpendicular to the long axis of the tooth, extending from the cementum to the alveolar bone (Nanci, 2019).

The oblique group is the most abundant of the periodontal ligament and has fibers that start from the cementum in an oblique direction, inserting into the alveolar bone in a more coronary position. The apical group, on the other hand, is distributed around the root apex, radiating from the cementum to the alveolar bone and attaching to the base of the alveolus. Finally, the interradicular group is present only in teeth with multiple roots, extending from the cementum to the alveolar bone in the region of the crest of the interradicular septum (Nanci, 2019).

Elastic fibers such as oxythalanes are present in the periodontal ligament, while elaunin fibers, also elastic, can be found in the gingival ligament (Nanci, 2019). Oxithalanic fibers are made up of bundles of microfibrils widely distributed in the periodontal ligament. They have a predominantly vertical orientation, extending from the surface of the cementum in the apical direction and forming a three-dimensional branched network that surrounds the tooth root and ends in the region of the apical complex, where arteries, veins and lymphatic vessels are located. In addition, these fibers maintain association with nerve bundles and small blood vessels. In the cervical region of the periodontal ligament, oxythalanic fibers are particularly numerous and dense, and are arranged parallel to the group of gingival collagen fibers (Nanci, 2019). Although their function is not yet fully understood, they are thought to play a role in regulating blood flow in response to masticatory function. Because they are part of the elastic system, they have the ability to stretch in the face of tension changes, allowing these variations to be transmitted and perceived by the walls of vascular structures. These characteristics reinforce the role of the periodontal ligament as a tissue capable of continuously adapting to the functional variations of mastication (Nanci, 2019).

Figure 12

Schematic representation of the main groups of periodontal ligament fibers - transeptal fibers, alveolar crest fibers, horizontal fibers, interradicular fibers, oblique fibers, and apical fibers



Source: Illustrated by the authors. Adapted from NEWMAN, Michael G.; ELANGOVAN, Satheesh; Irina F. Dragan; et al. Newman and Carranza - Essential Clinical Periodontics. Rio de Janeiro: GEN Guanabara Koogan, 2022, page 16, figure 2.3.

At the molecular and cellular levels, the loads on the periodontal ligament trigger mechanobiological events in the alveolar bone, which leads to bone remodeling, since the stretching of the periodontal ligament fibers causes increased blood flow, cell division, and fiber production, especially in orthodontic movements (Dutra *et al.*, 2016; Zhao *et al.*, 2025). This ability to adapt to forces is essential to allow controlled tooth movement and the maintenance of alveolar bone integrity (Dutra *et al.*, 2016).

Periodontal tissues derive from the neural crest, and it is precisely from remnants of these cells that CTLPs (Periodontal Ligament Stem Cells) with regenerative potential arise. In the microenvironment of the oral cavity, these cells are subjected to continuous and dynamic exposure to two predominant stimuli: mechanical forces and inflammatory signals (Nanci, 2019; Zhao *et al.*, 2025). In a physiological context, CTLPs respond to cyclic loads arising from normal chewing, while in orthodontic treatments, controlled forces are applied to stimulate these cells and promote programmed tooth movement.

However, in pathological scenarios, excessive mechanical stress—from occlusal trauma or inadequate orthodontic forces—can cause severe ligament damage, resulting in adverse outcomes such as root resorption or alveolar bone loss. In addition, the presence of inflammation of bacterial origin can trigger destructive processes in DPL, culminating in the degradation of soft tissues and adjacent bone structures (Zhao *et al.*, 2025). In this scenario, CTLPs emerge as central regulators, playing a decisive role both in the progression of

periodontal pathogenesis and in mediating therapeutic resolution and tissue remodeling. The characterization of these cells is based on specific criteria of multipotentiality and cellular markers defined in the specialized literature (Bartold; Gronthos, 2017). In addition, cell populations associated with blood vessels, such as pericytes, may also contribute to the regenerative potential of the periodontal ligament (Komaki, 2019). It is also observed that aging can reduce the proliferative and regenerative capacity of these cells, influencing tissue response throughout life (Tang & Yang, 2024).

Gingival innervation occurs through terminal branches of periodontal ligament fibers, in addition to contributions from the infraorbital, palatine or lingual, mentoni, and buccal nerves. In the inserted gingiva, most of the nerve endings are located in the lamina propria, and its presence among the epithelial cells is less frequent. There are specialized endings, such as nociceptors and mechanoreceptors, that allow the perception of pain, pressure, and touch. The presence of receptors in the periodontal ligament makes it possible to identify small forces applied to the teeth, which, in association with the proprioceptors of muscles and tendons, is essential for controlling movements and intensity of forces during chewing. In the mandible, the teeth and their periodontal ligaments are innervated by the inferior alveolar nerve, while in the maxilla, this innervation is performed by the superior alveolar plexus (Berglundh *et al.*, 2024).

3.4 ROOT HARVESTING

Cementum is characterized as an avascular mineralized connective tissue that plays the fundamental role of covering the root surfaces of dental elements. According to the precepts of Nanci (2019), the classification of this tissue is primarily based on two pillars: the presence or absence of cellular components embedded in its matrix and the nature of the origin of the collagen fibers that constitute it. The process of cementum formation, or cementogenesis, is structured in two distinct biological moments: the pre-functional stage, which covers the entire period of root development, and the functional stage, which is established when the tooth reaches the plane of occlusion, remaining active throughout the individual's life.

This temporal and structural differentiation results in types of cement with specific properties. The acellular cementum, formed early, plays the predominant role in the firm fixation of the tooth to the alveolus. On the other hand, cellular cementum has a markedly adaptive character, being deposited in response to physiological demands such as occlusal wear and tooth movement, in addition to having a direct and essential participation in the repair processes of periodontal tissues (Nanci, 2019).

According to the specialized literature (Nanci, 2019), the biochemical composition of cementum has a remarkable similarity with that of bone tissue, consisting of an inorganic phase of approximately 45% to 50% hydroxyapatite, while the remaining volume is filled with collagen and non-collagen proteins from the matrix. Type I collagen is established as the predominant organic component, representing 90% of the matrix in the cellular cementum of intrinsic fibers and playing a crucial role in structuring mineral deposition, in a manner equivalent to what occurs in osteogenesis. This protein is also essential in the periodontal ligament, where it organizes the bundles of fibers responsible for tooth anchorage and the dissipation of masticatory loads. In addition to type I collagen, the presence of type III collagen, associated with tissue development and repair processes, although its concentration declines with tissue maturation, and type XII collagen, which interacts with fibrils and non-collagen proteins to help maintain the functional integrity of the periodontal ligament in the face of occlusal forces. As Nanci (2019) points out, other variants, such as type V, VI, and XIV collagens, are detected in vestigial proportions in the mature cementum, possibly as byproducts of fibroblast activity from the adjacent periodontal ligament.

As for the non-collagen content, cementum shares with bone a number of signaling and structural molecules, including alkaline phosphatase, bone sialoprotein, osteocalcin, osteopontin, and several growth factors, as well as proteoglycans and proteolipids. However, research cited by Nanci (2019) suggests the existence of molecules potentially exclusive to this tissue, such as a specific adhesion protein and an insulin-analogous growth factor, whose full functional characterization still depends on complementary investigations. The biological similarity between cementoblasts and osteoblasts is further reinforced by the expression of the Bril protein, a membrane component characteristic of these cell lines, consolidating the ontogenetic and functional proximity between these two mineralized tissues.

With these constant depositions throughout life, different types of cementum are formed, which are classified according to Schroeder & Page (1990) as follows:

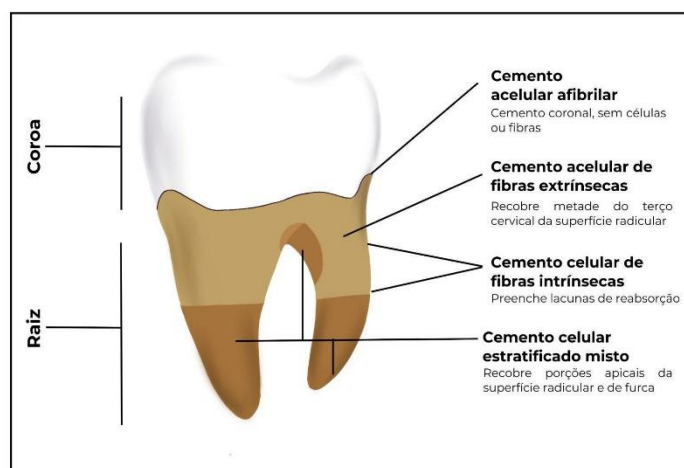
- 1) **Afibrillary acellular cementum** - is found in enamel, particularly along the cementary junction.
- 2) **Fibrillary acellular cementum** - it is composed almost entirely of bundles of Sharpey fibers (Sharpey's fibers). They are arranged perpendicular to the root surface, are thick and dispersed). It is often found at the cervical and middle root level. It is involved in the insertion of the tooth into the adjacent bone and has a potential for adaptation to functions such as mesial displacement and occlusal wear.
- 3) **Intrinsic fiber cellular cementum** - is initially deposited on the root surface in places where there is no acellular cementum of extrinsic fibers. It can be found in the apical

and furcation regions, and has no immediate function in the fixation of the teeth. (Intrinsic are produced by the oriented cementoblasts parallel to the long root axis, are delicate and clustered).

- 4) Mixed fiber cellular cementum** - is made up of both extrinsic and intrinsic fibers within a calcified matrix that contains cementocytes.

Figure 13

Types of cement with specific properties



Source: Illustrated by the authors. Adapted from NEWMAN, Michael G.; ELANGOVAN, Satheesh; Irina F. Dragan; et al. Newman and Carranza - Essential Clinical Periodontics. Rio de Janeiro: GEN Guanabara Koogan, 2022, page 18, figure 2.4.

The biological functions of cementum are fundamental for maintaining the integrity and position of the dental element in the arch, being categorized primarily as anchoring, adaptation and repair. Anchorage is made possible mainly by the acellular cementum of extrinsic fibers, with complementary participation of the mixed stratified cellular cementum; in both varieties, the insertion of Sharpey fibers is the mechanism that ensures effective attachment of the tooth to the socket (Newman *et al.*, 2022).

Regarding the adaptive function, it is mostly performed by the cellular cementum through a continuous deposition, especially in the apex and furcation regions, which allows to compensate for occlusal wear and maintain contact with the antagonist teeth. In addition, this deposition occurs more markedly on the distal surfaces to counteract the mesial physiological displacement of the teeth throughout life (Newman *et al.*, 2022).

In addition, the repair capacity of the periodontium is an attribute of the cellular cementum of intrinsic fibers, which is manifested in areas of root resorption or fracture lines. This repair process occurs in an accelerated manner and, because it usually lacks extrinsic

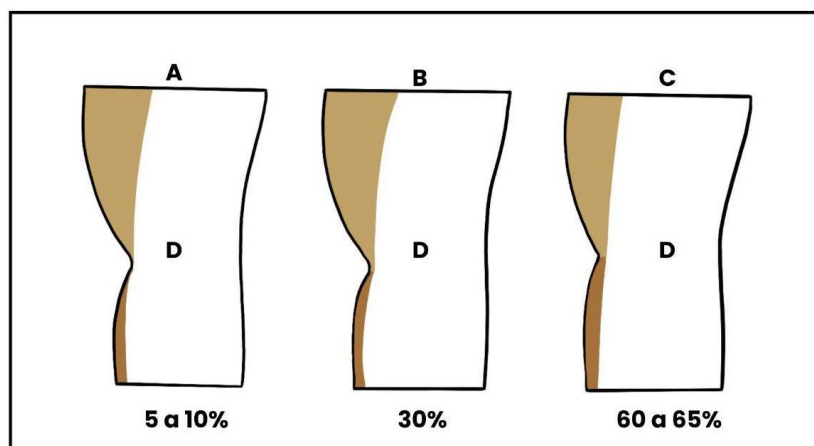
fibers in its initial phase, it focuses primarily on restoring tissue integrity and filling the defect, rather than acting directly on the immediate mechanical anchorage of the tooth (Newman *et al.*, 2020).

Cementum deposition occurs continuously throughout life, with variations in the rate of formation according to age and functional requirements, being more intense in the apical region, where it compensates for tooth eruption resulting from occlusal wear (Newman *et al.*, 2020). In the coronary half of the root, its thickness varies between 16 and 60 μm , while in the apical third and in the bifurcation areas it can reach 150 to 200 μm . The distal surfaces tend to be thicker than the mesial, possibly due to the physiological mesialization of the teeth. With aging, the average thickness of cementum can triple between 11 and 70 years, from about 95 μm at 20 years to approximately 215 μm at 60 years (Newman *et al.*, 2020).

Alterations in this process can generate hypercementosis, an exaggerated thickening that, although often physiological, can hinder extraction procedures or be associated with fibro-osseous pathologies.

The cementum of erupted teeth is subject to resorption, which may occur due to systemic and local causes such as occlusion trauma, orthodontic movement, pressure from erupting malpositioned teeth, reimplanted teeth, periapical and periodontal disease, vitamin D and A deficiency, calcium deficiency, hypothyroidism, Paget's disease, or may occur without apparent etiology (Newman *et al.*, 2020). Cementum is more resistant to resorption than alveolar bone. Due to their continuous growth, resorptions can be repaired if the intensity of the pressure is reduced and if the surrounding connective tissue remains intact.

There can be three different types of situations involving the relationship between cementum and enamel: a) in about 60 to 65% of cases, cementum overlaps enamel; b) in approximately 30% the union is top to top and; c) in 5 to 10% there is no union between cementum and enamel (Newman *et al.*, 2020).

Figure 14*The tooth support structures*

Source: Illustrated by the authors. Adapted from NEWMAN, Michael G.; ELANGOVAN, Satheesh; Irina F. Dragan; et al. Newman and Carranza - Essential Clinical Periodontics. Rio de Janeiro: GEN Guanabara Koogan, 2022, page 37, figure 2.14.

3.5 ALVEOLAR BONE

Together with LP and root cementum, the alveolar bone constitutes the supporting periodontium, whose main function is to distribute and absorb the stresses generated by mastication and other dental contacts (Berglundh *et al.*, 2024). The alveolar process consists of the maxilla and mandible bones that house the dental alveoli in their structure. The maintenance of the alveolar process depends on the presence of teeth and the stimulation they cause in the bone walls through collagen fibers of the periodontal ligament (Berglundh *et al.*, 2024).

The alveolar process is formed by different structural components that, although they can be described separately from an anatomical point of view, act in an integrated manner in the support of the teeth. Externally, it has a layer of cortical bone composed of Haversian bone and compact bone lamellae, providing strength and protection to the structure. Internally, the alveolar wall is made up of a thin layer of compact bone called the alveolar bone itself, which radiographically corresponds to the lamina dura. Histologically, this region has multiple perforations, characterizing the cribriform lamina, through which neurovascular bundles pass that connect the periodontal ligament to the central portion of the alveolar bone, represented by the cancellous bone. Between the two layers of compact bone are the spongy bone trabeculae, responsible for providing structural support to the alveolar process, and the interdental septum is formed by cancellous bone delimited by a layer of compact bone, supporting the adjacent teeth. In addition to these structures directly related to the teeth, the

maxillary include the basal bone, which is located more apically and is not directly related to the dental elements (Newman *et al.*, 2020).

The bone and wall of the sockets need to adapt to the forces of tension and deformation, as the teeth are constantly in motion. The plasticity of the hard lamina is reflected in the various morphologies (rigid, adhesive, woody, and continuous) of Sharpey fiber attachment (Nanci, 2019).

Osteoblasts are responsible for the formation of alveolar bone. During the mineralization process, some cells are incorporated and are called osteocytes. It is currently recognized that osteocytes act as mechanical sensors and regulators of bone remodeling, influencing the activity of osteoblasts and osteoclasts (Huang *et al.*, 2023). Osteoclasts play an essential complementary role in the remodeling of alveolar bone, promoting controlled resorption and allowing continuous renewal of bone tissue (Omi & Mishina, 2022).

According to the functional demand of the alveolar process, osteoblasts and osteoclasts perform bone matrix deposition and remodeling of the newly formed tissue. Thus, there is a balance between bone formation and resorption, but this can be altered by local and systemic factors. In inflammatory conditions, this balance can be disrupted by immune mediators that stimulate osteoclastic activity, a phenomenon described in the field of osteoimmunology (Tompkins, 2016). In areas where collagen fibers are under constant tension, bone matrix deposition occurs, and in areas under pressure, reabsorption occurs, which is believed to be caused by decreased vascularization and the number of cells at the site. Thus, it is suggested that the size and orientation of the bone trabeculae are related to the intensity of the stimulus to which they are exposed (Newman *et al.*, 2020).

3.6 PERIODONTAL PHYSIOLOGY

The blood supply to the periodontium derives primarily from the superior and inferior alveolar arteries, which emit the intraseptal artery before penetrating the alveolus. The terminal branches of the bone, known as perforating branches, penetrate the alveolar bone itself through the canals at all levels of the alveolus (Nanci, 2019; Berglundh *et al.*, 2024). In the space of the periodontal ligament, they anastomose with the blood vessels originating from the apical portion of the periodontal ligament and with the other terminal branches of the intraseptal artery. Before penetrating the root canal, the dental artery supplies branches that supply the apical portion of the periodontal ligament (Berglundh *et al.*, 2024).

The gingiva receives its blood supply primarily through the suprapariosteal blood vessels, which are terminal branches of the sublingual, chin, buccal, facial, greater palatine, infraorbital, and posterior superior dental arteries. In the periodontal ligament, the blood

vessels are organized in a polyhedral-shaped network that surrounds the entire tooth root. The free gingiva, on the other hand, receives blood supply from three main sources: suprapariosteal vessels, vessels originating from the periodontal ligament itself, and vessels originating from the alveolar bone (Berglundh *et al.*, 2024).

The periodontal ligament has a rich sensory innervation, and is largely supplied by nerve fibers capable of conducting tactile, pressure, and pain stimuli through the trigeminal nerve pathways. The nerve bundles reach the ligament from the periapical region and also through channels present in the alveolar bone, following the path of the blood vessels. Inside the ligament, these bundles are subdivided into myelinated fibers that, as they approach their endings, lose the myelin sheath and differentiate into four main types of nerve endings. Among them are the free endings, with an arboriform aspect, mainly responsible for the perception of pain; the Ruffini-type mechanoreceptors, located predominantly in the apical region; Meissner's spiral corpuscles, also mechanoreceptors, most often found in the middle third of the root; and the fusiform endings sensitive to pressure and vibration, surrounded by a fibrous capsule and located mainly in the region of the root apex. Thus, the regulation of masticatory movements and forces is due to the association of the proprioceptors of the muscles and tendons with the receptors of the periodontal ligament (Newman *et al.*, 2020; Berglundh *et al.*, 2024).

The ability to adapt quickly to functional changes while keeping its thickness relatively constant is a notable feature. This capacity is essential for the maintenance of tissue homeostasis, reflecting the performance of biological mechanisms responsible for regulating the metabolism and spatial organization of the cells involved in the formation of bone, cementum, and periodontal fibers. In addition, the cells of the periodontal ligament have a high capacity to produce and release several regulatory molecules, which plays an essential role in tissue remodeling processes and in maintaining the functional balance of the periodontal ligament (Newman *et al.*, 2020).

In general, the teeth and periodontal elements of the maxilla are innervated by the superior alveolar plexus. The maxillary gingiva is also innervated by the ramifications of the infraorbital nerves (buccal gingiva of the incisors, canines, and premolars), greater palatine (palatal gingiva of the molars and premolars), and nasopalatine nerves (palatal gingiva of the incisors and canines region) (Berglundh *et al.*, 2024). In the periodontium, small-caliber nerves largely follow the same path as blood vessels. In the gums, they travel through the most superficial connective tissue towards the periosteum and, along this path, emit several branches destined for the oral gingival epithelium, continuing to the region of the free gum.

The innervation of the periodontal ligament occurs both through the apical route, through branches of the dental nerve, and laterally, through the perforations in the wall of the alveolus, known as Volkmann's canals. Inside the ligament, these nerve fibers are grouped into larger bundles, which follow parallel to the longitudinal axis of the tooth. From these ascending bundles, small branches depart that supply specific areas of periodontal tissue (Berglundh *et al.*, 2024).

According to Berglundh *et al.* (2024), in the periodontium, lymphatic drainage is directed to the lymph nodes of the head and neck. In general, most of the teeth and their adjacent periodontal tissues drain into the submandibular lymph nodes. The gums of the mandibular incisor region drain primarily to the submental lymph nodes, while the palatal gingiva of the maxilla is directed to the deep cervical lymph nodes. The third molars, on the other hand, drain into the juguodigastric lymph nodes.

4 CONCLUSION

In short, the periodontium is configured as a dynamic biological unit, where tissue morphology is intrinsically linked to sensory and immunological functions. The current literature consolidates that the periodontium is not only a passive support, but a highly responsive system, because while the gingiva and the junctional epithelium guarantee the biological seal and the defense against pathogens, the periodontal ligament (DPL) acts as the main mechanobiological sensor of the complex.

The homeostasis of alveolar bone and root cementum is dictated by the ability of LPD to convert mechanical stimuli into biochemical signals, allowing continuous adaptation to masticatory and orthodontic loads. Therefore, the success of clinical interventions and regenerative therapies depends on the preservation of this functional integrity. Ultimately, detailed knowledge of periodontal physiology is the pillar that underpins safe and effective clinical decisions, allowing the dentist to act in harmony with the patient's biology to ensure biomechanical stability and long-term periodontal health.

ACKNOWLEDGMENTS

This study was funded by the Minas Gerais Research Support Foundation (FAPEMIG), the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financial Code 001 and the National Council for Scientific and Technological Development (CNPq) - INCT Oral Health and Dentistry - Scholarship n. 406840/2022-9.

REFERENCES

- Ambrosio, N., Marín, M. J., Laguna, E., Herrera, D., Sanz, M., & Figuero, E. (2019). Detection and quantification of *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* in bacteremia induced by interdental brushing. *Archives of Oral Biology*, 98, 213–219. <https://doi.org/10.1016/j.archoralbio.2018.11.025>
- Avila-Ortiz, G., Gonzalez-Martin, O., Couso-Queiruga, E., & Wang, H.-L. (2020). The peri-implant phenotype. *Journal of Periodontology*, 91(3), 283–288. <https://doi.org/10.1002/JPER.19-0566>
- Barros, S. P., Williams, R., Offenbacher, S., & Morelli, T. (2016). Gingival crevicular fluid as a source of biomarkers for periodontitis. *Periodontology 2000*, 70(1), 53–64. <https://doi.org/10.1111/prd.12107>
- Bartold, P. M., & Gronthos, S. (2017). Standardization of criteria defining periodontal ligament stem cells. *Journal of Dental Research*, 96(3), 231–238.
- Berglundh, T., Giannobile, W. V., Lang, N. P., Sanz, M., et al. (2024). *Lindhe – tratado de periodontia clínica e implantologia oral* (7ª ed.). Rio de Janeiro: Guanabara Koogan.
- Bertolini, P. F. R., et al. (2024). Invasão do espaço biológico. *Revista Eletrônica Acervo Saúde*, 24(12), 1–8. <https://doi.org/10.25248/REAS.e17930.2024>
- Caton, J. G., et al. (2018). A new classification scheme for periodontal and peri-implant diseases. *Journal of Clinical Periodontology*, 45(Suppl. 20), S1–S8.
- Chapple, I. L. C., et al. (2018). Periodontal health and gingival diseases. *Journal of Periodontology*, 89(Suppl. 1), S74–S84.
- Cortellini, P., & Bissada, N. F. (2018). Mucogingival conditions in the natural dentition. *Journal of Periodontology*, 89(Suppl. 1), S204–S213.
- De Jong, T., et al. (2017). The intricate anatomy of the periodontal ligament. *Journal of Periodontal Research*, 52(6), 965–974. <https://doi.org/10.1111/jre.12477>
- Dutra, E. H., Nanda, R., & Yadav, S. (2016). Bone response of loaded periodontal ligament. *Current Osteoporosis Reports*, 14(6), 280–283. <https://doi.org/10.1007/s11914-016-0328-X>
- Fatima, T., et al. (2021). Gingival crevicular fluid (GCF) as a diagnostic tool. *International Journal of Environmental Research and Public Health*, 18(6), 3038.
- Gargiulo, A. W., Wentz, F. M., & Orban, B. (1961). Dimensions of the dentogingival junction. *Journal of Periodontology*, 32(3), 261–267.
- Ghallab, N. A. (2018). Diagnostic potential of biomarkers in gingival crevicular fluid. *Archives of Oral Biology*, 87, 115–124.
- He, W., et al. (2023). Programmed cell death of periodontal ligament cells. *Journal of Cellular Physiology*, 238(8), 1743–1755.

- Huang, H., Yang, R., & Zhou, Y. H. (2022). Mechanobiology of periodontal ligament stem cells. *Journal of Dental Research*, 101(9), 1021–1030.
- Huang, X., et al. (2023). Roles of osteocytes in alveolar bone destruction. *Journal of Cellular Physiology*, 238(3), 567–579.
- Komaki, M. (2019). Pericytes in the periodontal ligament. *Advances in Experimental Medicine and Biology*, 1123, 187–199.
- Lang, N. P., & Bartold, P. M. (2018). Periodontal health. *Journal of Periodontology*, 89(Suppl. 1), S9–S16.
- Lyra, S. Q. P., Sampaio, R. I. F., & Oliveira, D. F. (2022). Biological space. *Research, Society and Development*, 11(7), e29814. <https://doi.org/10.33448/rsd-v11i7.29814>
- Nanci, A. (2019). *Ten Cate – histologia oral* (9^a ed.). Rio de Janeiro: Guanabara Koogan.
- Newman, M. G., et al. (2020). *Newman e Carranza – periodontia clínica* (13^a ed.). Rio de Janeiro: Guanabara Koogan.
- Newman, M. G., Elangovan, S., Dragan, I. F., et al. (2022). *Newman e Carranza – periodontia clínica essencial*. Rio de Janeiro: Guanabara Koogan.
- Omi, M., & Mishina, Y. (2022). Roles of osteoclasts in alveolar bone remodeling. *Journal of Bone and Mineral Research*, 37(8), 1415–1426.
- Schroeder, H. E., & Listgarten, M. A. (2003). The junctional epithelium. *Journal of Dental Research*, 82(3), 158–161. <https://doi.org/10.1177/154405910308200302>
- Tang, J., & Yang, K. (2024). Periodontal ligament stem cell aging. *Journal of Periodontal Research*, 59(2), 145–156.
- Theodoro, L. H., et al. (2023). Role of junctional epithelium. *Frontiers in Dental Medicine*, 4. <https://doi.org/10.3389/fdmed.2023.1144537>
- Tompkins, K. A. (2016). The osteoimmunology of alveolar bone loss. *Journal of Dental Research*, 95(7), 746–753.
- Wen, X., Pei, F., Jin, Y., & Zhao, Z. (2025). Mechanical and biological interplay in the periodontal ligament. *International Journal of Oral Science*, 17(1), 23. <https://doi.org/10.1038/s41368-025-00354-y>
- Yuan, X., et al. (2021). Comparative analyses of soft tissue interfaces. *Journal of Clinical Periodontology*, 48(5), 745–753. <https://doi.org/10.1111/jcpe.13446>
- Zhao, Z., et al. (2025). Periodontal ligament stem cells in tissue remodeling. *Stem Cell Research & Therapy*, 16(1), 653. <https://doi.org/10.1186/s13287-025-04777-6>

PROFILE OF MAXILLOFACIAL INJURIES IN WOMEN VICTIMS OF VIOLENCE FROM THE PERSPECTIVE OF FORENSIC ODONTOLOGY IN THE CITY OF JOÃO PESSOA, PARAÍBA

PERFIL DAS LESÕES MAXILOFACIAIS EM MULHERES VÍTIMAS DE VIOLÊNCIA SOB A PERSPECTIVA DA ODONTOLOGIA LEGAL NA CIDADE DE JOÃO PESSOA, PARAÍBA

PERFIL DE LESIONES MAXILOFACIALES EN MUJERES VÍCTIMAS DE VIOLENCIA DESDE LA PERSPECTIVA DE LA ODONTOLOGÍA FORENSE



<https://doi.org/10.56238/sevened2026.021-004>

Giselle Moreira de Carvalho¹, Joelly Pinheiro da Silva², Sabrina André Silva³, Rebeka Maria de Sousa Feitosa⁴, Rafaella Araújo Amancio de Lima Medeiros⁵, Luísa Simões de Albuquerque⁶, Wanúbia Barbosa Nunes⁷, Tayná Ribeiro Monteiro de Figueiredo⁸

ABSTRACT

Violence against women manifests itself in various forms, including psychological abuse, threats, physical assaults, and femicide, frequently associated with dental and maxillofacial trauma. This study aimed to describe the profile of domestic and community violence against women and to identify patterns of oro-maxillofacial trauma from an odontolegal perspective. To this end, data from the Legal Medicine and Dentistry Center of the metropolitan region of João Pessoa, covering the period from January to December 2019, were analyzed. Victims of physical assault who underwent forensic examination were included, excluding records unavailable due to legal issues. Data collection used a form containing sociodemographic variables, characteristics of the violence, and trauma. Descriptive and inferential statistical analysis was performed, with logistic regression using the backward Wald method and the

¹ Graduated in Dentistry. Universidade Estadual da Paraíba (UEPB). E-mail: gimoreirac@gmail.com
Orcid: <https://orcid.org/0000-0003-4788-7254> Lattes: <http://lattes.cnpq.br/3210630596394458>

² Graduated in Dentistry. Universidade Estadual da Paraíba (UEPB). E-mail: joelly.piinheiro@gmail.com
Orcid: <https://orcid.org/0009-0000-9385-5216> Lattes: <https://lattes.cnpq.br/4929460595387162>

³ Graduated in Dentistry. Universidade Estadual da Paraíba (UEPB).
E-mail: sabrina.andre@outlook.com Orcid: <https://orcid.org/0000-0001-5418-4333>
Lattes: <http://lattes.cnpq.br/5341593322936434>

⁴ Graduated in Dentistry. Universidade Estadual da Paraíba (UEPB).
E-mail: rebeka.feitosa@aluno.eupb.edu.br Orcid: <https://orcid.org/0000-0002-5207-9027>
Lattes: <http://lattes.cnpq.br/6025386609586949>

⁵ Master's degree in Dentistry. Universidade Estadual da Paraíba (UEPB).
E-mail: rafaella_amancio@hotmail.com Orcid: <https://orcid.org/0000-0001-9221-8020>
Lattes: <http://lattes.cnpq.br/7078747553600034>

⁶ Master's degree in Dentistry. Universidade Estadual da Paraíba (UEPB). E-mail: luisasimoesa@gmail.com
Orcid: <https://orcid.org/0000-0001-7448-7868> Lattes: <https://lattes.cnpq.br/9721364647222362>

⁷ Master's degree in Dentistry. Universidade Estadual da Paraíba (UEPB). E-mail: wanubia.bn@gmail.com
Orcid: <https://orcid.org/0000-0001-8866-9996> Lattes: <http://lattes.cnpq.br/6853452891541203>

⁸ Dr. in Dentistry. Universidade Estadual da Paraíba (UEPB). E-mail: taynaribeiromf@gmail.com
Orcid: <https://orcid.org/0000-0002-2111-4651> Lattes: <https://lattes.cnpq.br/9344742389589571>

Hosmer-Lemeshow test, using SPSS 22.0 software. It was observed that most victims were between 30 and 59 years old, had a partner, were salaried employees, and had low levels of education. The aggressors were predominantly men, usually partners of the victims. The assaults occurred mainly on Sundays, at night, in the home, and mostly without the use of weapons. The most frequent pattern was multiple bodily traumas, while isolated facial traumas mainly affected the orbital region. It is concluded that it was possible to outline the profile of the violence and highlight an association between unarmed assaults and a higher probability of facial trauma.

Keywords: Forensic Dentistry. Maxillofacial Trauma. Violence Against Women. Public Health.

RESUMO

A violência contra mulheres manifesta-se de diversas formas, incluindo abuso psicológico, ameaças, agressões físicas e feminicídio, frequentemente associados a traumas dentários e maxilofaciais. Objetivou-se descrever o perfil da violência doméstica e comunitária contra a mulher e identificar padrões de traumas oro-maxilo-faciais sob a perspectiva odontolegal. Para tanto, procede-se à análise de dados do Núcleo de Medicina e Odontologia Legal da região metropolitana de João Pessoa, referentes ao período de janeiro a dezembro de 2019. Incluíram-se vítimas de agressão física submetidas a exame de corpo de delito, excluindo-se registros indisponíveis por questões judiciais. A coleta de dados utilizou formulário contendo variáveis sociodemográficas, características da violência e dos traumas. Realizou-se análise estatística descritiva e inferencial, com regressão logística pelo método backward Wald e teste de Hosmer-Lemeshow, utilizando o software SPSS 22.0. Observou-se que a maioria das vítimas tinha entre 30 e 59 anos, possuía companheiro, era assalariada e apresentava baixa escolaridade. Os agressores eram predominantemente homens, geralmente parceiros das vítimas. As agressões ocorreram principalmente aos domingos, à noite, na residência, e em sua maioria sem uso de armas. O padrão mais frequente foi de múltiplos traumas corporais, enquanto traumas faciais isolados afetaram sobretudo a região orbital. Conclui-se que foi possível delinear o perfil da violência e evidenciar associação entre agressões sem armas e maior probabilidade de trauma facial.

Palavras-chave: Odontologia Legal. Traumatismos Maxilofaciais. Violência contra a Mulher. Saúde Pública.

RESUMEN

La violencia contra las mujeres se manifiesta de diversas formas, incluyendo abuso psicológico, amenazas, agresiones físicas y feminicidio, frecuentemente asociado con traumatismos dentales y maxilofaciales. Este estudio tuvo como objetivo describir el perfil de la violencia doméstica y comunitaria contra las mujeres e identificar patrones de traumatismos oromaxilofaciales desde una perspectiva odontológica legal. Para ello, se analizaron datos del Centro de Medicina Legal y Odontología de la región metropolitana de João Pessoa, correspondientes al período de enero a diciembre de 2019. Se incluyeron víctimas de agresión física que se sometieron a examen forense, excluyendo los registros no disponibles por motivos legales. La recolección de datos se realizó mediante un formulario que contenía variables sociodemográficas, características de la violencia y traumatismos. Se realizó un análisis estadístico descriptivo e inferencial, con regresión logística mediante el método de Wald hacia atrás y la prueba de Hosmer-Lemeshow, utilizando el software SPSS 22.0. Se observó que la mayoría de las víctimas tenían entre 30 y 59 años, tenían pareja, eran empleadas asalariadas y presentaban bajos niveles de educación. Los agresores eran predominantemente hombres, generalmente parejas de las víctimas. Las agresiones ocurrieron principalmente los domingos, de noche, en el domicilio y, en su mayoría, sin el uso de armas. El patrón más frecuente fueron los traumatismos corporales múltiples,

mientras que los traumatismos faciales aislados afectaron principalmente la región orbital. Se concluye que fue posible perfilar la violencia y destacar una asociación entre las agresiones sin armas y una mayor probabilidad de traumatismo facial.

Palabras clave: Odontología Forense. Traumatismo Maxilofacial. Violencia Contra las Mujeres. Salud Pública.

1 INTRODUCTION

Violence against women, an alarming problem in contemporary society, takes multiple forms, from psychological abuse and threats, to physical aggression and femicide (Cavalcante *et al.*, 2020). The World Health Organization (WHO) defines violence against women as any act or conduct based on gender that may result in physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether in the social or private sphere, and its occurrence is recognized as a public health problem (Castro *et al.*, 2017; Oliveira *et al.*, 2019).

Domestic violence is the term used to designate violence that occurs in the family environment, between family members or between intimate partners, while community violence commonly occurs in places other than homes, between known or unknown individuals (Bernardino *et al.*, 2017; Castro *et al.*, 2017). Domestic violence is the most common violence against women, being closely related to gender violence, which highlights the unequal position of women in society, where the vast majority of aggressors are partners, parents, children, followed by ex-partners, acquaintances, and neighbors (Bispo *et al.*, 2022; Soares *et al.*, 2018).

Exposure to violence is often related to dental and maxillofacial trauma. The face is one of the most unique regions of the human body, cooperating with self-image and self-esteem, signifying attractiveness and beauty, especially for women (Bernardino *et al.*, 2018). Because it is located at the level of the aggressor's ascending arm, the face is easily reached, and the aggression against it aims to intimidate and disfigure the victim's identity, being considered one of the most relevant aggressions, due to the possibility of permanent functional consequences, in addition to the aesthetic and psychological damage that can negatively impact the well-being and quality of life of the victims (Cavalcante *et al.*, 2020; Rodrigues *et al.*, 2020).

Emergency hospitals receive and treat many victims of interpersonal violence, especially the most severe cases (Bernardino *et al.*, 2017). In addition, most individuals who exhibit injuries related to physical aggression are directed to undergo forensic examinations in Forensic Medicine and Dentistry Centers, where meticulous data analysis can contribute to the progress of scientific knowledge related not only to the pattern of trauma exhibited by the victims, but also to the circumstances and context in which the violence occurs (Cavalcante *et al.*, 2020).

In this sense, the objective of this study was to describe the profile of domestic and community violence against women and to determine the pattern of oro-maxillofacial traumas from a dentist-legal perspective.

2 THEORETICAL FRAMEWORK

2.1 REPRESENTATION OF VIOLENCE AGAINST WOMEN

Unquestionably, more and more, women occupy social positions that were exclusively male. However, this change did not alter the culture of female submission, which is closely linked to the situations of gender violence, suffered by the fact of being a woman, originating from the association of social, cultural, and biological factors, associated with an inequality of power based on a macho logic (Cruz, Espíndola, Trindade, 2017; Soares *et al.*, 2018; Belolli, Santos, De Bortoli, 2024). Although men and women coexist in society with similar risk factors, there are behavioral characteristics that determine a pattern of victimization by violence specific to each of them, which can be explained by biological, psychological, cultural and sociological issues. Historically, men have been pointed out as the main perpetrators, which can be attributed to the process of construction of male identity, often permeated by elements such as power, aggressiveness, and virility, facilitating participation in violent episodes (Cavalcante *et al.*, 2020).

According to the WHO, 35% of women worldwide are victims of physical and/or sexual aggression, being generated in the family environment, in most cases, from current or former partners (Barufaldi *et al.*, 2017; Nunes *et al.*, 2022). In Brazil, violence against women is considered one of the main forms of human rights violations and has increased significantly in the last three decades, leading the country to have one of the highest rates of violence recorded in the world (Bernardino *et al.*, 2018; Barbosa *et al.*, 2019). In the Northeast region, studies also point to a gradual increase in cases of domestic violence, which may be directly related to the empowerment of women to report and consequently the increase in the number of notifications (Barbosa *et al.*, 2019; Figueiredo *et al.*, 2020; Santos *et al.*, 2021).

2.2 EFFECTS OF VIOLENCE AGAINST WOMEN

One of the main reasons for violence against women to be recognized globally as a public health problem is the large body of evidence on its impacts on women's health. Exposure to violence is associated with outcomes such as anxiety, depression, emotional and mental damage, sexually transmitted diseases, post-traumatic stress disorder (PTSD), psychoactive substance abuse, and suicidal ideation (Bernardino *et al.*, 2017; Bernardino *et al.*, 2024; Stockl, Sorenson, 2024).

In the big picture, domestic violence also results in unwanted pregnancies, miscarriages, and behavioral problems in young children who witness violent behavior against their mothers, in addition to the social isolation of victims due to poor acceptance and prejudice, which makes them susceptible and with few coping strategies. In addition, there

are situations of violence that result in femicide, which are practiced by a reaction of hatred against women, such as when she has autonomy, expressing a social structure that interprets the female body as a territory of occupation and violence, culminating in non-occasional deaths (Moroskoski *et al.*, 2021; Belolli, Santos, De Bortoli, 2024).

In this way, violence against women becomes a health problem that has a great impact on individual and collective quality of life, in view of the physical, psychic and moral injuries it causes, as well as due to the demands for attention and care in medical-hospital services in view of the existing notifications (Santos *et al.*, 2021; Stockol, Sorenson, 2024).

2.3 ANALYSIS OF PHYSICAL AGGRESSION

Women who are the target of violence are more likely to face emotional, psychological, and physical challenges, including traumatic oral injuries and impact on oral health (Bernardino *et al.*, 2018). The face is one of the most unique regions of the human body, encompassing anatomical structures that are fundamental for activities such as breathing, chewing, swallowing, speaking and social interaction. Due to their greater exposure to the aggressor and the relative lack of protection, the area comprising the head and neck becomes especially susceptible to physical aggression. In addition to injuries in general, about 76% - 94% of victims suffer facial injuries, which can result in permanent functional changes (Boyes, Fan, 2020; Nunes *et al.*, 2022).

The most prevalent oral and maxillofacial traumas resulting from cases of violence are contusions, fractures and burns, usually produced by direct aggression (freehand), instrumentalized (bladed and firearms) or mixed, and should be immediately treated due to the risk of resulting in sequelae such as scars, masticatory dysfunction, tooth loss and even emotional damage that refers to the memory of the painful abuse suffered (Cavalcante *et al.*, 2020; Nunes *et al.*, 2022).

2.4 ASSISTANCE TO VICTIMS AND REMEDIAL MEASURES

Understanding the patterns of injuries that affect women victims of violence, as well as diagnosis and epidemiology, contributes to the detection of violent episodes, the formulation of public security policies and guidance on the conduct of health professionals in cases of violence against women (Batista *et al.*, 2021). The information obtained from medical and legal reports of episodes of physical aggression can contribute substantially to the decision-making process, creation of prevention strategies, and better knowledge about the forms of interaction between health sciences and law (Bernardino *et al.*, 2018).

Despite significant advances in public policies to combat violence against women, many challenges persist, such as the underreporting of cases of violence, cultural resistance that often minimizes or normalizes these situations, and the lack of adequate resources for the effective implementation of existing policies. In addition, continuous training of professionals and expanded access to support services are still insufficient in many regions, especially in the most vulnerable areas. More efforts are essential to promote broader awareness of the seriousness of the problem of violence against women, in addition to ensuring that women know their rights and the resources available (Bernardino *et al.*, 2016; Garcia, 2016; Oliveira *et al.*, 2019; Figueiredo *et al.*, 2020).

3 METHODOLOGY

This is an observational, exploratory study, with secondary data from the Center for Forensic Medicine and Dentistry (NUMOL) in the metropolitan region of João Pessoa, in the Northeast of Brazil, which has a population estimated at approximately 1,304,280 inhabitants (IBGE, 2022 Census), integrated by the municipalities of João Pessoa, Bayeux, Cabedelo, Conde, Cruz do Espírito Santo, Lucena, Rio Tinto, Santa Rita, Alhandra, Caaporã, Pedras de Fogo and Pitimbu.

All records of victims who suffered physical aggression and were submitted to a forensic examination, recorded over the course of one year (January 2019 to December 2019), were adopted as inclusion criteria. The exclusion criteria were records that were unavailable at the time of collection due to legal reasons. In addition, because the filling of the records was handwritten, manuscripts that were illegible were also excluded.

For data collection, a specific form was developed that contained variables related to the social and demographic characteristics of the victims (region of residence, age, marital status, education, occupation, skin color), characteristics of interpersonal violence (circumstance of violence, aggressor sex, aggressor subject, instrument used), characteristics of the occurrence (day of occurrence, time of occurrence, place of the event) and traumas suffered by the victims (region of the body, presence of facial trauma, type of facial trauma, facial region) (Table 1).

Table 1

Distribution of variables and categorization

Independent variables	Categorization
Region of residence	João Pessoa Metropolitan Region
Age of the victim	00 to 09 years old 10 to 19 years old

	20 to 29 years old 30 to 59 years old 60 years or older Not informed
Marital status of the victim	With partner No companion Not informed
Victim's education	Illiterate ≤ 8 years of study Between 8 and 11 years of study > 11 years of study Not informed
Victim's occupation	Stand-alone Salaried Retired Unemployed Doesn't work Student Not informed
Victim's skin color	White Black Brown Yellow Indigenous Not informed
Circumstance of violence	Family friendly Community Not informed
Sex of the aggressor	Women Male Both Not informed
Aggressor subject	Partner/Boyfriend Ex-partner/Ex-boyfriend Family friendly Known Strange More than one Not informed
Instrument used	Naked assaults Firearm Bladed weapon Other means More than one Not applicable Not informed
Day of occurrence	Monday Tuesday Wednesday Thursday Friday Saturday Sunday Not informed
Time of occurrence	00:00 to 05:59 06:00 to 11:59 12:00 to 17:59 6:00 pm to 11:59 pm Not informed
Event location	Victim's home Other Address Not informed

Affected body region	Head/Temporal/Headset Face Neck/Nape Thorax/Clavicle/Mammary Abdomen/Flank Back/Lumbar/Cervical/Back Upper limb/Scapular Lower limb/gluteal/genital More than one region affected Not informed
Facial trauma	Gift Absent
Type of facial trauma	Soft tissue(s) of the face Facial bone fracture Dentoalveolar More than one type of trauma Not applicable Not informed
Affected face region	Orbital/Peri/Infra/Eyelid/Superciliary Front Lip Nasal Zygomatic/Malar Buccinator (external) Jaw/Geniana Jaw Chin Teeth Language Gums More than one region affected Not applicable Not informed

Source: Prepared by the authors.

Descriptive statistical analysis was performed to characterize the sample and describe the main variables of the study. For inferential statistics, a logistic regression was performed, considering the characteristic of the dependent variable (dichotomous). The independent variables are categorical and were included in the block model, the first block with variables related to the victim: age, skin color, marital status, education and occupation. The second block had variables related to violence: circumstance of violence, sex of the aggressor, aggressor subject, place of the event. And finally, the last block with variables related to the weapon used in the aggression: naked assault, firearm, bladed weapon, other means and more than one method. The backward:wald method was adopted, adopting $p < 0.200$ as a criterion for the adjusted model. The Hosmer-Lemeshow test was used to evaluate the quality of the model. The analyses were performed using the SPSS software, version 22.0.

The development of this study followed the ethical principles of research involving human beings, as presupposed by Resolution 196/96. The project was registered in SISNEP (National Information System on Ethics in Research involving Human Beings) independently evaluated by a Research Ethics Committee, and was approved (CAAE:

74238823.3.0000.5187). All the rights of the victims were protected and the national and international precepts of ethics in research with human beings were followed.

4 RESULTS AND DISCUSSIONS

During the period investigated, 1,280 cases of domestic and community violence against women were registered. The distribution of victims according to sociodemographic characteristics revealed that most of them were aged between 30 and 59 years (45.4%), with a partner (52.7%), with more than 11 years of schooling (8.2%) and salaried (42.0%). Skin color was mostly brown (73.8%) (Table 2).

Table 2

Sample description: absolute and percentage values for variables related to the victims

Variables	n	%
Age group		
00 to 09 years old	23	1,8%
10 to 19 years old	171	13,4%
20 to 29 years old	447	34,9%
30 to 59 years old	581	45,4%
60 years or older	36	2,8%
Not informed	22	1,7%
Marital Status		
With partner	675	52,7%
No companion	531	41,5%
Not informed	74	5,8%
Education		
Illiterate	6	0,5%
≤ 8 years of study	23	1,8%
Between 8 and 11 years of study	58	4,5%
> 11 years of study	105	8,2%
Not informed	1088	85,0%
Occupation		
Stand-alone	91	7,1%
Salaried	537	42,0%
Retired	32	2,5%
Unemployed	31	2,4%
Doesn't work	237	18,5%
Student	173	13,5%
Not informed	179	14,0%
Skin color		
White	12	0,9%
Black	5	0,4%
Brown	945	73,8%
Yellow	1	0,1%
Indigenous	0	0,0%
Not informed	317	24,8%

Source: Prepared by the authors.

In the distribution of women for the variables related to the characteristics of violence, situations of aggression prevailed in the municipality of João Pessoa (72.7%), in which most victims sought the Women's Police Station (64.1%). Family violence (66.9%), perpetrated

mostly by a male aggressor (69.6%), usually a partner (35.6%). The records were mainly on Sundays (21.0%), in the night shift (31.4%) and at the victim's home (36.6%) (Table 3).

Table 3

Sample description: absolute and percentage values for variables related to the characteristics of violence

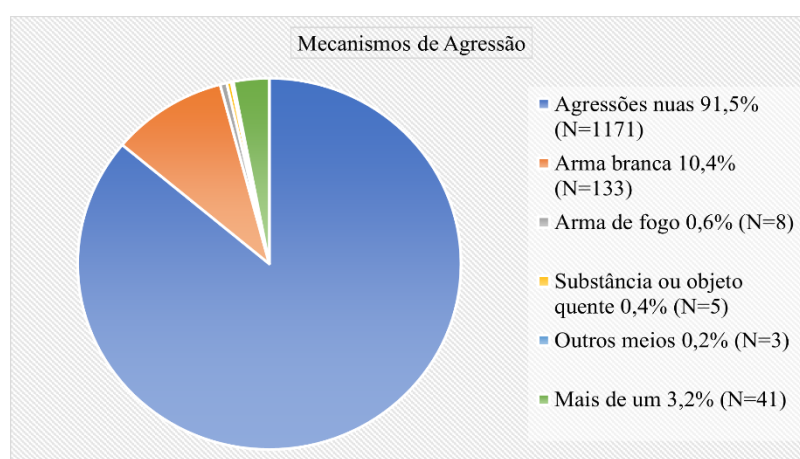
Variables	n	%
Place of dispatch		
Centralized Duty	29	2,3%
District Police Station	343	26,8%
Women's Police Station	820	64,1%
Childhood and Youth Police Station	70	5,5%
Justice	3	0,2%
Specialized Police Station for Elderly Care	12	0,9%
Homophobic Crimes Police Station	3	0,2%
Region of residence		
João Pessoa	930	72,7%
Metropolitan Region	347	27,1%
Not informed	3	0,3%
Circumstance of Violence		
Family friendly	856	66,9%
Community	381	29,8%
Not informed	43	3,4%
Sex		
Women	332	25,9%
Male	891	69,6%
Both	44	3,4%
Not informed	13	1,0%
Aggressor subject		
Partner/Boyfriend	456	35,6%
Ex-partner/Ex-boyfriend	201	15,7%
Family friendly	186	14,5%
Known	324	25,3%
Strange	56	4,4%
More than one aggressor from different categories	11	0,9%
Not informed	46	3,6%
Day of occurrence		
Monday	170	13,3%
Tuesday	135	10,5%
Wednesday	150	11,7%
Thursday	137	10,7%
Friday	151	11,8%
Saturday	209	16,3%
Sunday	269	21,0%
Not informed	59	4,6%
Time of occurrence		
00:00 to 05:59	140	10,9%
06:00 to 11:59	260	20,3%
12:00 to 17:59	291	22,7%
6:00 pm to 11:59 pm	402	31,4%
Not informed	187	14,7%
Event location		
Victim's residence	468	36,6%
Other Address	392	30,6%
Not informed	420	32,8%

Source: Prepared by the authors.

Regarding the mechanism of aggression, situations of aggression without an instrument were predominant 91.5% (N=1,171), followed by the use of a knife 10.4% (N=133), firearm 0.6% (N=8) and hot substance or object 0.4% (N=5). There was an occurrence of 3.2% (N=41) of aggressions characterized by the presence of more than one mechanism of aggression (Figure 1).

Figure 1

Sample description: absolute values and percentages for variables related to the instrument of violence



Source: Prepared by the authors.

Trauma in more than one region of the body was the most frequent pattern (55.4%), followed by isolated cases of trauma in the upper/scapular limb (64.2%) and isolated trauma in the facial region (48.7%) (Table 4).

Table 4

Sample description: absolute and percentage values for variables related to the region of the body affected by violence

Affected body region	n	%
Head/Temporal/Headset		
No	1124	87,8%
Yes	156	12,2%
Face		
No	657	51,3%
Yes	623	48,7%
Neck/Nape		
No	1181	92,3%
Yes	99	7,7%
Thorax/Clavicle/Mammary		
No	1136	88,8%
Yes	144	11,2%
Abdomen/Flank		
No	1239	96,8%
Yes	41	3,2%
Back/Lumbar/Cervical/Back		

No	1150	89,8%
Yes	130	10,2%
Upper/Scapular Limb		
No	458	35,8%
Yes	822	64,2%
Lower Limb/Gluteal/Genital		
No	889	69,5%
Yes	391	30,5%
More than one location		
No	571	44,6%
Yes	709	55,4%

Source: Prepared by the authors.

The distribution of women victims of family and community violence according to the type of facial trauma showed injuries in the soft tissues of the face (51.2%), dentoalveolar trauma (1.1%) and facial bone fracture (0.9%). The affected facial region had a decreasing pattern of lesions in the orbital/periorbital/infraorbital/eyelid/superciliary (17.5%), labial (17.0%), frontal (12.7%), zygomatic/malar (9.1%), nasal (7.0%), mandible/genial (6.5%), buccinator (4.6%), chin (2.7%), teeth (1.1%), gingiva (0.6%) and maxilla (0.1%) areas. 1.3% were more than one type of trauma and 21.4% more than one region of the face affected (Table 5).

Table 5

Sample description: absolute and percentage values for variables related to facial trauma, its type and affected region

Variables	n	%
Facial trauma		
Absent	655	51,2%
Gift	625	48,8%
Soft tissues of the face		
No	6	0,5%
Yes	619	48,4%
Not applicable	655	51,2%
Facial bone fracture		
No	614	48,0%
Yes	11	0,9%
Not applicable	655	51,2%
Dentoalveolar trauma		
No	611	47,7%
Yes	14	1,1%
Not applicable	655	51,2%
More than one type of trauma to the face		
No	609	47,6%
Yes	16	1,3%
Not applicable	655	51,2%
Orbital/peri/infra/eyelid/superciliary		
No	397	31,0%
Yes	224	17,5%
Not applicable	655	51,2%
Front		
No	461	36,0%
Yes	162	12,7%
Not applicable	655	51,2%

Lip		
No	406	31,7%
Yes	217	17,0%
Not applicable	655	51,2%
Nasal		
No	534	41,7%
Yes	89	7,0%
Not applicable	655	51,2%
Zygomatic/Malar		
No	507	39,6%
Yes	116	9,1%
Not applicable	655	51,2%
Buccinator (external)		
No	564	44,1%
Yes	59	4,6%
Not applicable	655	51,2%
Jaw/Geniana		
No	540	42,2%
Yes	83	6,5%
Not applicable	655	51,2%
Jaw		
No	622	48,6%
Yes	1	0,1%
Not applicable	655	51,2%
Chin		
No	589	46,0%
Yes	34	2,7%
Not applicable	655	51,2%
Teeth		
No	609	47,6%
Yes	14	1,1%
Not applicable	655	51,2%
Language		
No	623	48,7%
Yes	0	0,0%
Not applicable	655	51,2%
Gums		
No	615	48,0%
Yes	8	0,6%
Not applicable	655	51,2%
More than one area of the face		
No	349	27,3%
Yes	274	21,4%
Not applicable	655	51,2%

Source: Prepared by the authors.

Linear regression, the final analysis after adjusting the model, showed that women raped by naked aggression are three times more likely to present facial trauma. The variable sex of the aggressor was also significant, however, the OR value (0.998)* indicates a very low, almost insignificant protection factor (Table 6).

*If the sex is different, the chance of aggression decreases by 0.2%, so it is not considered, being practically nil, not contributing to increase or decrease the chances of trauma in a substantial way.

Table 6

Adjusted logistic regression model for the analysis of variables associated with facial trauma in women victims of violence

Variable	95% CI			p-value
	OR	Bottom	Superior	
Skin color	1,000	1,000	1,000	0,298
Sex	0,998	0,996	1,000	0,034
Event location	1,000	1,000	1,000	0,048
Naked assaults	3,159	1,981	5,038	0,000
Burns	6,089	0,752	49,307	0,091

Source: Prepared by the authors.

The most affected age group in this study was between 30 and 59 years old. In agreement, Oliveira *et al.* (2019) indicated that older women face a higher risk of suffering physical violence compared to younger women (48.1%), approaching the mean age found in Figueiredo *et al.* (2020), which was 32.0%, comprising, in general, a group of women of young adult age. This may be based on the hypothesis that older women are economically more productive and socially influential, being less tied to dependencies, tend to feel less fear and have a greater propensity to report, which favors a reduction in underreporting rates (Garcia, 2016).

However, in a study carried out in Patos-PB (Félix *et al.*, 2020) the age group between 21 and 30 years old was the most affected, followed by the group between 31 and 40 years old, approaching the average age observed in a study developed in Paraná (Belloli, Santos, De Bortoli, 2024), which was 29.5 years for victims who made complaints. Similar to a study conducted in the United Kingdom (Fan, 2020), where the average age of patients who were victims of domestic violence was 28 years old. Based on the same hypothesis that as they age, women tend to start a more productive and socially influential phase, it is possible that they will become less likely to report recent cases of violence, since, even if they have been exposed to a circumstance of violence, they may have had the opportunity to detach themselves from this scenario, and for this reason they no longer seek care (Campos *et al.*, 2016; Figueiredo *et al.*, 2020).

From the educational and occupational point of view, most of the victims had schooling > 11 years of schooling and a salaried employment relationship. In this conjunction, it agrees with recent studies in which schooling can be understood as a factor in the reduction of underreporting, due to the fact that most of the notifications are of victims with schooling > 8 years of schooling, which can be associated with a higher level of education and knowledge of their rights (Oliveira *et al.*, 2019; Belloli, Santos, De Bortoli, 2024). Regarding occupation, the findings were consistent with studies in the literature that show the victims having an employment relationship and a monthly income of up to two minimum wages (Soares *et al.*,

2018; Contreras, Portillo, Rodríguez, 2019). However, other studies have linked situations of violence to victims who have not completed elementary school and do not work (Barbosa *et al.*, 2019; Figueiredo *et al.*, 2020). The absence of information related to monthly income in the records represents a significant limitation of this study, since it prevents the accurate representation of real income.

This relationship can be explained by the fact that women who do not perform gratified services tend to develop jobs that do not require technical training, domestic activities or manual work at home and consequently have more contact with aggressors (Félix *et al.*, 2020; Batista *et al.*, 2021). In a complementary way, articles have listed low wages or unemployment as a detrimental factor to access to consumer goods or services, with a consequent impact on quality of life, well-being and emotional state, contributing to a scenario of financial dependence that makes it difficult for the victim to sever ties with the aggressor (Oliveira *et al.*, 2019; Bernardino *et al.*, 2024).

With regard to marital status, this study revealed that 52.7% of the forensic victims have a partner, characterizing a condition of family violence (66.9%). Similar to the findings in Félix *et al.* (2020) and Santos *et al.* (2021), where most cases of women in situations of gender violence were those who have an affective bond with the aggressor. The data differs from a study carried out in the state of Ceará that proved that although most aggressors are partners or ex-partners, more than 60% of the victims are single or divorced/separated women (Oliveira *et al.*, 2019). As well as in the study carried out with men in criminal proceedings resulting from violence against women, who reported being separated maritally (Lírio *et al.*, 2019). In addition, other studies have observed that women were also assaulted by known individuals, which may be a neighbor or even a brother, pointing to the greater vulnerability of women in conflicts with regard to affective relationships or blood ties (Bernardino *et al.*, 2017; Contreras, Portillo, Rodríguez, 2019; Cavalcante *et al.*, 2020).

Violence against women perpetrated by partners or ex-partners is an alarming manifestation of gender inequalities resulting from a structural machismo rooted in society (Félix, *et al.* 2020). The dynamics of dependence, both emotional and economic, perpetuate a vicious cycle of submission and control, where women are reduced to a condition of extreme vulnerability. The prevalence of gender-based violence, which disproportionately affects women, reflects a culture that has historically minimized their rights and dignity, with devastating repercussions not only on the physical and mental health of victims, but also on quality of life and self-esteem (Cruz, Espíndola, Trindade, 2017; Soares *et al.*, 2018).

Regarding the characteristics of the occurrence, records prevailed on Sundays (21.0%), at night (31.4%), at the victim's home (36.6%). As well as Oliveira *et al.* (2019)

observed that the first two working days of the week were the days with the highest number of complaints, showing a higher incidence of aggression on the weekend, as did Castro *et al.* (2017). Similar to Figueiredo *et al.* (2020), a study in which records on Sundays and the night shift prevailed.

As for the mechanisms of aggression, naked aggressions stood out, followed by the use of bladed weapons and firearms. Consistent with previous findings in studies that mainly confirmed the use of physical force, mainly fist and foot blows, as a means to practice violence (Bernardino *et al.*, 2017; Cavalcante *et al.* 2020; Batista *et al.*, 2021). As well as Santos *et al.* (2021) observed that the instrument of aggression is generally blunt, followed in descending order by sharp objects, firearms, and hot object/fluid, in addition to the predominance of physical violence followed by psychological/moral and sexual violence. One hypothesis that can elucidate the high incidence of naked aggression is that this type of violence represents a strategy of the aggressor to exert control and humiliation over the victim in a direct and ostensive way, this approach accentuates the victim's vulnerability and reinforces the dynamics of domination that permeates the abusive relationship (Cruz, Espíndola, Trindade, 2017).

Among the main injuries that occurred after the aggressions, the most frequent pattern is trauma in more than one region of the body (upper limbs and face), as in Castro *et al.* (2017) and Figueiredo *et al.* (2020). Considering the cases of isolated traumas in the head region, abrasions, hematoma, ecchymosis and edema in soft tissues, in the orbital and labial regions, predominated, according to Batista *et al.* (2021) cites ecchymosis and hematomas as the most common lesions, and both the orbits and lips as the most affected structures, as they are regions formed by loose subcutaneous tissue, favoring the appearance of these lesions. These findings were in agreement with other studies (Garcez *et al.*, 2019; Rodrigues *et al.*, 2020; Sá *et al.*, 2020; Nunes *et al.*, 2022) who also observed milder traumas in soft tissue regions, in addition to more severe traumas such as fractures of facial bones, especially in the frontal, orbital, zygomatic, and mandibular regions. Oliveira *et al.* (2019) also points out that, even in cases where the dental tissue is affected, they are determined to be mild in nature, especially in situations of: sensitivity, mobility and fracture of enamel alone without involvement of the dental organ.

Linear regression, the final analysis after adjusting the model, showed that women who are victims of naked aggression are three times more likely to suffer facial trauma, which may be associated with the positioning of the face at the height of the aggressor's raised arm, favoring the face region to be affected. Such a scenario generates great personal and social impact, since the face is one of the most unique areas of the human body, related to female

identity and aesthetics and interpersonal communication (Boyes, Fan, 2020; Nunes *et al.*, 2022). The upper limbs are also among the most affected regions of the body, as they could be used for self-defense, protection, and to mitigate injuries resulting from conflicts (Cavalcante *et al.*, 2020; Rodrigues *et al.*, 2020).

5 CONCLUSION

The profile of violence against women was formed by young-adult victims, with partners, salaried workers, occurrences on Sundays, during the night shift and aggressions affecting more than one region of the body. The pattern of maxillofacial lesions included soft tissue lesions, hematoma-type, ecchymosis, abrasions, and edema, followed by dentoalveolar trauma and fractures of the facial bones. The place most affected by violence in the craniofacial region was the upper third, especially the orbit.

Most of the injuries were caused by naked aggression, by the aggressor's own hands, who, in most cases, was the victim's own partner, including cases of domestic violence. It was found that there is a significant association between women raped by naked aggression and a three-fold greater chance of facial trauma.

REFERENCES

- Barbosa, K., et al. (2019). Epidemiological and spatial characteristics of interpersonal physical violence in a Brazilian city: A comparative study of violent injury hotspots in familial versus non-familial settings, 2012–2014. *PLOS ONE*, 14(1), 1–19.
- Barufaldi, L., et al. (2017). Violência de gênero: Comparação da mortalidade por agressão em mulheres com e sem notificação prévia de violência. *Ciência & Saúde Coletiva*, 22(9), 2929–2938.
- Batista, A., et al. (2021). Lesões orofaciais em mulheres vítimas de violência não fatal: Uma revisão integrativa. *Revista Brasileira de Odontologia Legal*, 8(2), 59–72.
- Belloli, M., Santos, V., & De Bortoli, C. (2024). Estudo retrospectivo do perfil dos casos de violência contra a mulher. *Journal of Nursing and Health*, 14(2), e1426804.
- Bernardino, Í., et al. (2018). Intimate partner violence against women, circumstances of aggressions and oral-maxillofacial traumas: A medical-legal and forensic approach. *Legal Medicine*, 31, 1–6.
- Bernardino, Í., et al. (2024). Spatial–temporal distribution of maxillofacial injuries resulting from intimate partner violence against women. *Dental Traumatology*, 40(2), 82–90.
- Bernardino, Í., et al. (2017). Violência interpessoal, circunstâncias das agressões e padrões dos traumas maxilofaciais na região metropolitana de Campina Grande, Paraíba, Brasil (2008–2011). *Ciência & Saúde Coletiva*, 22(9), 3033–3044.

- Bernardino, Í., et al. (2016). Violência contra mulheres em diferentes estágios do ciclo de vida no Brasil: Um estudo exploratório. *Revista Brasileira de Epidemiologia*, 19(4), 740–752.
- Bispo, J., et al. (2022). Violência contra a mulher: Educação em saúde em uma unidade básica de saúde em Maceió. *Extensão em Foco*, 26, 249–258.
- Boyes, H., & Fan, K. (2020). Maxillofacial injuries associated with domestic violence: Experience at a major trauma centre. *British Journal of Oral and Maxillofacial Surgery*, 58(2), 185–189.
- Campos, M., et al. (2016). Análise de lesões orofaciais registradas no Instituto Médico-Legal de São Luís (MA), no período de 2011–2013. *Revista Brasileira de Odontologia Legal*, 21–31.
- Castro, R., Cerellino, L., & Rivera, R. (2017). Risk factors of violence against women in Peru. *Journal of Family Violence*, 32(8), 807–815.
- Castro, T., et al. (2017). Violence against women: Characteristics of head and neck injuries. *RGO – Revista Gaúcha de Odontologia*, 65(2), 100–108.
- Cavalcante, G., et al. (2020). Facial injuries and the gender issue: Expressions of violence in a metropolitan region of northeastern Brazil. *Brazilian Dental Journal*, 31(5), 548–556.
- Contreras, I., Vilardy, E., & Rodríguez, M. (2019). Prevalence of maxillofacial injuries in women who have experienced physical violence reported at a House of Justice in the metropolitan area of Bucaramanga (Colombia). *Revista Facultad de Odontología*, 31(1–2), 102–111.
- Cruz, S., Espíndula, D., & Trindade, Z. (2017). Violência de gênero e seus autores: Representações dos profissionais de saúde. *Psico-USF*, 22(3), 555–567.
- Felix, R., et al. (2020). Perfil das lesões maxilofaciais em mulheres vítimas de violência periciadas em uma cidade do estado da Paraíba. *Revista Brasileira de Odontologia Legal*, 7(3), 12–22.
- Figueiredo, T., et al. (2020). Violência intrafamiliar e comunitária contra mulheres: Um problema de saúde pública. *Revista Interdisciplinar em Saúde*, 7(1), 1215–1229.
- Garcez, R., et al. (2019). Caracterização de lesões bucomaxilofaciais decorrentes de agressão física: Diferenças entre gênero. *Ciência & Saúde Coletiva*, 24(3), 1143–1152.
- Garcia, L. (2016). A magnitude invisível da violência contra a mulher. *Epidemiologia e Serviços de Saúde*, 25(3), 451–454.
- Lírio, J., et al. (2019). Elements which precipitate conjugal violence: The discourse of men in criminal prosecution. *Revista da Escola de Enfermagem da USP*, 53, 28–36.
- Moroskoski, M., et al. (2021). Aumento da violência física contra a mulher perpetrada pelo parceiro íntimo: Uma análise de tendência. *Ciência & Saúde Coletiva*, 26(3), 4993–5002.

- Nunes, J., et al. (2023). Lesões bucomaxilofaciais decorrentes de violência doméstica contra mulheres: Uma revisão integrativa. *Revista Brasileira de Odontologia Legal*, 9(3), 105–114.
- Oliveira, M., et al. (2019). Análise temporal das agressões físicas contra a mulher sob a perspectiva da odontologia legal na cidade de Fortaleza, Ceará. *Revista Brasileira de Odontologia Legal*, 2–14.
- Rodrigues, L., et al. (2019). Trends of maxillofacial injuries resulting from physical violence in Brazil. *Dental Traumatology*, 36(1), 69–75.
- Sá, C., et al. (2020). Maxillofacial and dental-related injuries from a Brazilian forensic science institute: Victims and perpetrators characteristics and associated risk factors. *Journal of Clinical and Experimental Dentistry*, 736–744.
- Santos, V., et al. (2021). Violência doméstica no Nordeste: Uma análise dos dados do sistema de informação de agravos e notificação (SINAN) entre 2009 e 2018. *Research, Society and Development*, 10(13), 5–13.
- Soares, E., et al. (2018). Análise pericial das lesões situadas em cabeça e pescoço de mulheres vítimas de violência doméstica atendidas em um instituto médico legal de Maceió – AL. *Revista Brasileira de Odontologia Legal*, 12–22.
- Stöckl, H., & Sorenson, S. (2024). Violence against women as a global public health issue. *Annual Review of Public Health*, 45(1), 277–294.

BEHAVIOR OF THE ORAL AND MAXILLOFACIAL ORTHOPEDIC IMPLANT
COMPORTAMENTO DO IMPLANTE ORTOPÉDICO DE BUCOMAXILO
COMPORTAMIENTO DEL IMPLANTE ORTOPÉDICO BUCOMAXILOFACIAL



<https://doi.org/10.56238/sevened2026.021-005>

Antoniane Arantes de Oliveira Roque¹, Luis Fernando dos Santos², William Augusto Guimarães³

ABSTRACT

The treatment of mandibular fractures has improved significantly over the past 30 years. Minimally invasive high-concept surgical techniques have emerged with the aim of promoting accelerated restoration of mandibular function, ensuring better airway control, improving speech, enhancing oral hygiene by reducing the risk of infections, and ultimately enabling patients to return earlier to their routine and work activities. The present study aimed to demonstrate the mechanical behavior of an orthopedic implant plate for the maxillofacial region, the benefit of osteointegration promoted by it, as well as its role in providing bone stabilization during the patient's recovery process. The results presented in the scientific literature, clinical studies, and data obtained from mechanical testing performed on the products (static pull-out, torque and removal, traction, chemical analysis, and metallography) support the safety and efficacy of the system for its intended and indicated use. Thus, it is concluded that, when the system is used according to its intended purpose, the clinical benefits for the patient outweigh the possible risks associated with its use.

Keywords: Forensic Dentistry. Maxillofacial Trauma. Violence Against Women. Public Health.

RESUMO

O tratamento de fraturas mandibulares melhorou muito nos últimos 30 anos, técnicas cirúrgicas minimamente invasivas de alto conceito surgiram com o objetivo de promover a restauração acelerada da função mandibular, promover um melhor controle das vias áreas, melhorar a fala, melhorar a higiene bucal reduzindo o risco de infecções, e, por fim, a promoção mais precoce do paciente às suas atividades de rotinas e trabalho. O presente trabalho objetivou a demonstração do comportamento mecânico de uma placa de implante ortopédico para a região de bucomaxilo facial, o benefício da osteo integração promovido por ela, além de fornecer a estabilização óssea durante o processo de recuperação do

¹ Dr. in Environment and Society. Faculdades Integradas Maria Imaculada (FIMI).

E-mail: antoniane@yahoo.com.br Orcid: <https://orcid.org/0000-0002-3005-251X>

Lattes: <http://lattes.cnpq.br/6640077134951410>

² Mechanical Engineer. Faculdades Integradas Maria Imaculada (FIMI). E-mail: Issantos486@gmail.com

Orcid: <https://orcid.org/0009-0000-9458-9132>

³ Mechanical Engineer. Faculdades Integradas Maria Imaculada (FIMI). E-mail: w.a.guimaraes@outlook.com

Orcid: <https://orcid.org/0009-0000-9845-4673>

paciente. Os resultados apresentados na literatura científica, dos estudos clínicos e dos dados obtidos com os ensaios mecânicos realizados nos produtos (arrancamento estático, torque e remoção, tração, análise química, e metalografia) substanciam a segurança e eficácia do sistema para o uso indicado e destinado. Assim, conclui-se que, se o sistema for utilizado de acordo com o uso indicado e destinado, os benefícios clínicos para o paciente suplantam os possíveis riscos da utilização do produto.

Palavras-chave: Fratura. Mandíbula. Técnicas Cirúrgicas. Estabilização Óssea.

RESUMEN

El tratamiento de las fracturas mandibulares ha mejorado mucho en los últimos 30 años. Han surgido técnicas quirúrgicas mínimamente invasivas de alto concepto con el objetivo de promover la restauración acelerada de la función mandibular, mejorar el control de las vías aéreas, mejorar el habla, mejorar la higiene bucal reduciendo el riesgo de infecciones y, finalmente, favorecer el retorno más temprano del paciente a sus actividades rutinarias y laborales. El presente trabajo tuvo como objetivo demostrar el comportamiento mecánico de una placa de implante ortopédico para la región maxilofacial, el beneficio de la osteointegración promovida por ella, así como proporcionar la estabilización ósea durante el proceso de recuperación del paciente. Los resultados presentados en la literatura científica, los estudios clínicos y los datos obtenidos de los ensayos mecánicos realizados en los productos (arrancamiento estático, torque y remoción, tracción, análisis químico y metalografía) sustentan la seguridad y eficacia del sistema para su uso indicado y destinado. Así, se concluye que, si el sistema se utiliza de acuerdo con su indicación, los beneficios clínicos para el paciente superan los posibles riesgos de su uso.

Palabras clave: Fractura. Mandíbula. Técnicas Quirúrgicas. Estabilización Ósea.

1 INTRODUCTION

Karam and Lopes (2005) say that orthopedics arose due to the need to correct deformities in human beings, and that it is constantly improving through generations. On the subject, Meyer (2002) points out that the Egyptians and Chinese were the first peoples to show signs of orthopedic therapeutic use, where many laymen confused medicine with healers, giving rise to several professions related to the area, such as physiotherapy, osteopathy, chiropractic.

There is also the evaluation of Vivacqua and Elias (2012) where they state that, in order to understand the study of bone reconstruction and its regeneration, it is necessary to know its physiology, structure, and mechanical behavior.

In the segment of analysis and behavior of prostheses/implants in relation to bone behavior, Dunlop and Fratzl (2010) report that the bone structure has elastic properties and plastic properties. Such properties promote protection and support through intrinsic behaviors, promoted by the mineralized collagen matrix, which is constituted of a trabeculated structural arrangement, that is, composed of small beams. Currey (2006) says that the trabecular structure is responsible for absorbing the stresses generated by impacts and external forces, causing reversible elastic deformation.

For a better understanding of how bone is formed, it is explained that bone tissue is composed of organic and inorganic parts, where the organic part is responsible for the strength of the bone, being formed by 95% collagen, which determines bone growth factors. While the hardness of the bone originates in the inorganic part, it is formed by calcium phosphate, calcium carbonate, magnesium phosphate, sodium chloride and calcium chloride, as exposed by Junqueira and Carneiro (2017).

To understand the function of an implant, it is important to understand that the basic principle of primary bone healing occurs only in conditions of absolute stability, therefore, all forces applied to the mandible must be neutralized through rigid internal fixation, because, according to Lazow and Tarlo (2009), during the act of chewing, forces such as tension, torsion, compression and shear.

According to data from the World Health Organization, oral and maxillofacial trauma is one of the leading causes of disability and death in the world. They are usually caused by external agents and are attributed to violent means, such as accidents, falls and assaults. Ramos *et al.* (2018) point out that each year it is estimated that 1.24 million people die as a result of these traumas, half of these deaths are represented by head and face injuries, however, most of these people survive these injuries, leaving them with permanent limiting sequelae.

As for the treatment of jaw fractures, the adaptive mini plates have been the treatment suggested by expert surgeons, this type of treatment includes many advantages such as restoring jaw function, controlling the airway, improving the patient's nutritional status, improving speech development, improving oral hygiene during the recovery period, improved recovery of self-esteem, improved psychological health, and early return to professional activities and daily routines (Lazow and Tarlo, 2009).

From 1992 to 2007, SUNY Brooklyn County Hospital treated 2,311 maxillofacial oral fractures, of which only 2.4% required reoperation, bone healing was satisfactory in 99% of cases for DCP (Dynamic Compression Plates) reconstruction plates. After this period, the use of 2 mm locked plates was tested and the result of the test was that this type of plate provided greater stabilization, favoring the osteointegration procedure, also allowing to reduce the postoperative period from 2 weeks to 1 week. The application is carried out with a plate and locking screw, this concept is due to the screw having a thread in its head and the plate having a thread in the internal diameter of the hole, where the mechanical locking between the parts occurs, and the limitation of the traction of the screw with the bone, reducing the rupture stress (Lazow and Tarlo, 2009).

Thus, there is a need to apply orthopedic plates for oral and maxillofacial reconstruction, which are supplied by the medical device manufacturing industries, and applied by specialized medical surgeons, through surgical techniques developed for each type of medical device. Thus, the objective of this work is: 1) to understand the behavior of orthopedic implants during the process of osteointegration, 2) to analyze the mechanical behavior of orthopedic plate implants for the boxmaxillary segment, through tests performed in the laboratory, and 3) to demonstrate the advantages that the use of mini fixation plates offer during the patient's recovery through studies already carried out.

2 MATERIAL AND METHODS

All the tests obtained and presented in this article were provided by a company in the market segment, called Company X in the present work, which obtained the results of the mechanical tests through accredited laboratories certified by the most renowned certifying bodies, such as REBLAS – Brazilian Network of Analytical Laboratory in Health, and ABNT NBR ISO/IEC 17025:2005.

This article is extremely important in terms of regulation, as it provides the basis for the regulation of certification requirements and product registrations with ANVISA (National Health Surveillance Agency), the certifying body in Brazil responsible for granting registration

of health products, and the results of the tests are provided by a reputable company, a manufacturer of orthopedic implants.

The tests are linked to bending, mechanical fatigue, insertion and removal of screws, and torsion, as they are material behaviors, of essential importance for analysis, to simulate the mechanical behavior of the implant during the process of osteointegration, because bone regeneration is not simply the gluing of two parts that are separated, they have traction and compression movements, that lack bone stabilization for the formation of regenerated bone tissue.

2.1 SAMPLE IDENTIFICATION

01 sampling of 5 2.7x12 mm cortical screws made of titanium was tested, following the ASTM F136-11 - 2021 standard – Standard Specification for Wrought Titanium 6 Aluminum 4, Vanadium (Extra Low Interstitial) Alloy for Surgical Implant Applications, which is part of a system of non-locked plates and screws, that is, a system of non-rigid fixation plates. The screw is completely threaded, with a symmetrical thread, cylindrical and solid body, conical tip, and rounded head inner surface, as shown in Figure 1, next to the ruler with units in centimeters.

Figure 1

Specimen before the test.



Source: Authors, 2023.

The surface finish is polished and passivated, which makes it, after a passivation process, a surface with greater resistance to corrosion. The technical, geometric, and nominal information are described in table 1.

Table 1

Dimensional information of the specimen

Description	Larger Diameter	Smaller Diameter	Screw Length	Thread pitch	Head Height	Thread Length
Face value	2.7 mm	1.9 mm	12 mm	0.9 mm	2.0 mm	10.0 mm
Samples						
Sample identification		Code		Plot	Lab ID	
Screw 1.6x10mm		PFSC16.10		01010	CP 1234-1	
Screw 2.9x10mm		PFSC19.10		01010	CP 1234-2	
Screw 2.1x10mm		PFSC21.10		01010	CP 1234-3	
Screw 2.4x10mm		PFSC24.10		01010	CP 1234-4	

Source: Authors, 2023.

2.2 TEST PROCEDURE - STATIC PULLOUT

The product was subjected to the static pullout test according to ASTM F543 - 2023 – Standard Specification and Test Methods Medical Bone Screws. The Static Screw Pullout Test was performed with the purpose of determining the maximum pullout force.

For each test, the screw was inserted into a block of standard material, which performed the function of the bone, with dimensions of 30x180x40 mm. The material chosen was grade 40 PCF rigid polyurethane foam, according to ASTM F1839 - 2021 Standard Specification for Rigid Polyurethane Foam for use as a Material for Test Orthopedic Devices Instruments.

Before the insertion of the screw, a hole of 2.0 mm was opened, without previous threading, maintaining a distance of 36 mm between holes, for insertion of the screw in the block was used an equipment with centralized that guarantees the perpendicularity between the upper surface of the block, and the longitudinal axis of the screw, the insertion speed was 3 rpm (rotation per minute), with an insertion depth (H) of 6 mm +/- 0.25 mm.

The test block with the inserted screw has been adjusted to the test device fixed at the base of the machine, ensuring alignment between the direction of application of the load and the longitudinal axis of the screw.

The test was conducted in displacement control, with a constant speed of 5mm/minute and the Newton (N) x displacement in millimeters (mm) force curve was obtained for each of the tested specimens.

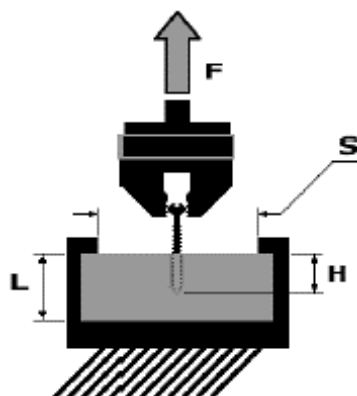
The end of the test was associated with the moment of screw pullout or its rupture and a pressure space (S) of (24mm +/- 0.25mm) and test blocks with a height L of 40.0 mm were used.

The machine that performed the test is a Universal Mechanical Testing Equipment - Servo Mechanical 5 - with a 500N force transducer and its operation can be identified through

the representation of Figure 2. The tests were carried out in dry with a temperature of 20.0 $\pm$ 5°C.

Figure 2

Screw pullout test



Source: Universal Mechanical Testing Equipment Manual, 2023.

2.3 TORQUE AND REMOVAL TESTS

The product was subjected to the static torque test of screw insertion and removal according to ASTM F543 – Standard Specification for Test Methods for Metallic Medical Bone Screws. These tests were carried out with the purpose of determining the maximum insertion and removal torque values.

For each screw insertion and removal test, a block of standard material was used that performs the function of a bone substitute, with nominal dimensions of 30x180x40 mm. The material chosen was the rigid polyurethane foam block grade 40 PFC, according to the technical standard ASTM F1839 – Standard Specification for Rigid Polyurethane Foam for use as a Standard Material for Teste Orthopedic Devices and Instruments.

Before inserting the screw, a previous hole of 2.0 mm was opened, without threading, maintaining a distance of 36 mm between holes, for insertion of the screw in the block, a polyurethane bushing was used that will serve as a centering guide in order to ensure perpendicularity with the surface.

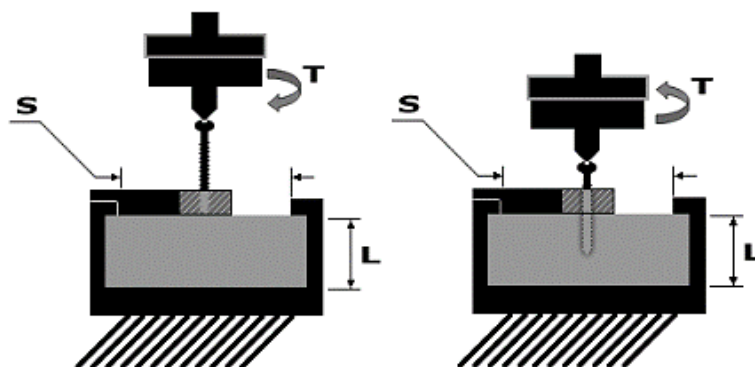
The test block was adjusted to the device and fixed to the testing machine, the application of the twist was performed with a bit key. The test was conducted at a speed of 5 rpm (revolutions per minute) and the torque curve in Newton multiplied by meter (Nm) x angle in degrees (°) was obtained for each of the test bodies tested.

The machine that performed the test was a Universal Mechanical Testing Equipment - Servo Hydraulic 4 - with a 1000-pulse encoder, 0.5 Nm torque transducer. Figure 3 shows

the operation of the equipment that was used to perform the torque test in the implant device. The tests were carried out in dry with a temperature of $20.0 \pm 5^\circ\text{C}$.

Figure 3

Screw Insertion and Removal Torque Test



Source: Universal Mechanical Testing Equipment Manual, 2023.

2.4 TENSILE TESTS ON TITANIUM ALLOY SPECIMEN

The test determined the mechanical tensile properties in a titanium alloy sample, in order to determine the yield stress limits, tensile strength limit, and elongation limit, according to the ASTM E8 E8M-11 - 2013 – Standard Test Methods for Tension Testing of Metallic Materials.

A sample of Titanium Bar 6Al4VELI alloy, $\varnothing$ 3.18mm, and a plate of Titanium ASTM F67 - 2017, Grade 4, thickness of 0.63 mm, were analyzed.

Tensile tests for the titanium bar were conducted according to ASTM E8/E8M-11, according to the requirements of ASTM F136-11 (Standard Specification for Wrought Titanium-6 Aluminum-4 Vanadium ELI – Extra Low Interstitial – Alloy for Surgical Implant Applications). The procedure was performed at room temperature, in a universal testing machine model 5585H – INSTRON, with a maximum capacity of 250 kN (kilogram Newton), the test parameters are presented in Table 2.

Table 2

Results obtained in test according to standard

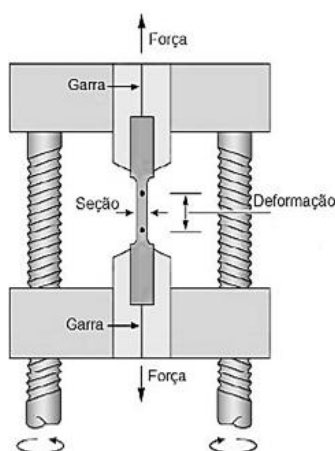
Employee		Reference – ASTM F136-11
Usable length – I0	12.7 mm (D=3.18 mm)	4D - 4W - 2 inches
Parallel length – IC	80 mm	—
Speed from crosshead to drain	0.5 mm/min	0.003 – 0.007 mm/mm/min
Beam Speed after Drainage	20 mm/min	The velocity was increased so that the fracture occurs in approximately 1 minute.

Source: Authors, based on ASTM F136-11, 2023.

Tensile tests for the titanium plate were conducted according to ASTM E8/E8M-11, according to the requirement of ASTM F67-06 (Standard Specification for Unalloyed Titanium, for Surgical Implant Applications (UNS R50250, UNS R50400, UNS R50550, UNS R50700)). The procedure took place at room temperature, in a universal testing machine model 5585H – INSTRON, with a maximum capacity of 250 kN, as shown in Figure 4, which demonstrates the tensile test procedure that was performed.

Figure 4

Tensile test



Source: Biopdi, 2022.

2.5 CHEMICAL ANALYSIS TESTS ON TITANIUM ALLOY SAMPLE

The purpose of this test is to determine the metal constituents and chemical composition in titanium alloy specimen by verifying compliance with ASTM F136-11 specification.

The sample that was tested refers to a Titanium bar, 6Al4VELI bar Ø (diameter) 3.18mm. The elements of interest were determined by induced plasma optical emission spectrometry, in a laboratory accredited by ANVISA. The equipment used was a VISTA from the Varian brand. Carbon was determined by direct combustion in LECO CS-444 equipment.

Oxygen and Nitrogen were determined by infrared radiation absorption and thermoconductivity difference, respectively, in LECO TC-436 equipment. Hydrogen was determined by a difference in thermoconductivity in LECO RH-402 equipment.

2.6 METALLOGRAPHY TESTS ON TITANIUM ALLOY SPECIMEN

The objective of the test was to evaluate the microstructure of a titanium plate sample, according to ASTM F67 – 06 - Standard Specification for Unalloyed Titanium, for Surgical Implant Applications and NBR ISO 5832–2 - 01 (Implants for surgery - Metallic materials. Part 2: Pure Titanium).

The specimen refers to an ASTM F67 Grade 2 Titanium plate, thickness of 2.0mm, and the metallographic analysis was conducted based on ASTM F–7 - 06 - Standard Specification for Unalloyed Titanium, for Surgical Implant Applications; item 9.1 – Alpha case and ISO 5832-2: - 01 - Implants for surgery – Metallic materials. Part 2: Pure Titanium; i–in 4 - Microstructure.

The sample was prepared in the usual way, going through the stages of embing, sanding, polishing and chemical etching with the appropriate reagent. The sample was observed under a Leitz Laborlux 12ME S – Leica optical microscope.

3 RESULTS AND DISCUSSION

3.1 ABOUT THE RAW MATERIAL

The plates and bolts are constructed of titanium, in accordance with ASTM F67 and ASTM F136 - 2021 standards, respectively. Table 3 presents the results of the chemical characterization test of the raw material for the manufacture of plates in pure Titanium ASTM F67, grade 1, identified by lot 123456, referring to a 9.5mm plate.

Table 3

Chemical composition (elements) and reference for titanium TiCp, grade 4

	N	C	H	O	Faith	Ti
ASTM F67, Grade 1	0.03 max.	0.08 max.	0.015 max	0.18 max.	0.20 max.	Balance
Lot 123456	0,002	0,02	0,003	0,10	0,10	Balance

Source: Company X, 2022.

In Table 4, the mechanical properties of the lot are compared with the reference values. According to what is presented in the inspection reports, the raw material used meets the ASTM F67 standard.

Table 4

Mechanical properties of the batch and reference values

	Minimum Tensile Strength (MPa)	Minimum Flow Strength (MPa)	Minimum Elongation Percentage (%)
ASTM F67, Grade 4	170	240	24
Lot 123456	451	322	32

Source: Company X, 2022.

Table 5 shows the normative criteria that the material used must meet in order to be in accordance with the ASTM F67 standard, referring to the requirements relevant to the metallographic conditions, and the presence of a "α case" phase is not allowed.

Table 5

Lot microstructure properties and reference

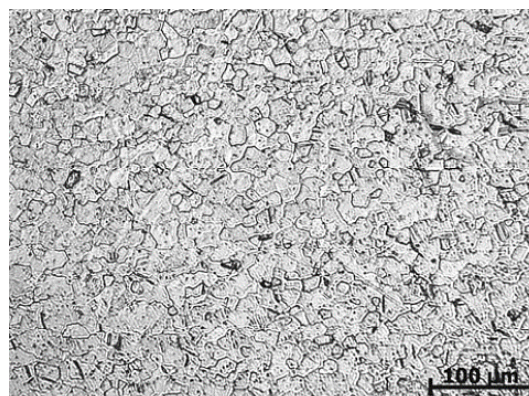
	Grain Size	Alpha Case	Compliance
Lot 123456	7.0	Absence of the "α case" phase	As required by standard
ASTM F67 Standard	5 or more refined.		

Source: Company X, 2022.

Figure 5 shows the microstructure in a cross-sectional image, verifying the absence of a "α case" phase.

Figure 5

Microstructure of the MET111988 sample, in cross-section



Source: Company X, 2022.

According to what is presented in the inspection reports, the raw material used meets the ASTM F67 standard, grade 1 and its composition is shown in table 6.

The result of the chemical characterization tests of the raw material for the manufacture of screws in Titanium Alloy ASTM F136 - 2021, identified by lot 123456, referring to a 3mm billet, meets the ASTM F136 - 2021 standard.

Table 6

Chemical composition (elements) and reference for titanium alloy Ti6Al4V

	Al	V	Faith	O	C	N	H	Ti
ASTM F136	5,5-6,5	3,5-4,5	0.25 max.	0.13 max.	0.08 max.	0.05 max	0.012 max	Balance
Lot 123456	6,47	4,02	0,20	0,12	0,02	0,004	0,006	Balance

Source: Company X, 2022.

Table 7 shows that the material sample was submitted to tests to determine the Tensile Strength, yield strength, percentage of elongation and area reduction, such properties are extremely important for the correct performance of the implant function.

Table 7

Mechanical properties of the lot and reference values

	Tensile Strength Min. (MPa)	Min Flow Limit (MPa)	Min Stretch. (%)	Reduction of Min Area. (%)
ASTM F136	860	795	10	25
Lot 123456	1110	953	13	45

Source: Company X, 2022.

Table 8 shows the normative criteria that the material used must meet in order to be in accordance with the ASTM F136 - 2021 standard, and their results. In this case, the desired result is the fine dispersion of alpha and beta phases, resulting from processing in the alpha plus beta field. There should be no continuous alpha lattice on primary beta grain boundaries. There should be no coarse and elongated alpha platelets.

Table 8

Lot microstructure properties and reference

	Structural Requirement
ASTM F136 Standard	Finely dispersed α and β phases, absence of continuous lattice α phase, absence of coarse or platelet α phases, and absence of phase α case Finely dispersed α and β phases. Absence of the α phase in continuous lattice in the old grain contours of the β phase. Absence of coarse α phase and elongated platelets. No " α case" phase allowed
Lot 123456	As required by standard

Source: EmpresaX, 2022.

According to what is presented in the inspection reports, the raw material used meets the ASTM F136 – 2021 standard.

3.2 MECHANICAL EVALUATION – ACCEPTANCE CRITERIA FOR PLATES

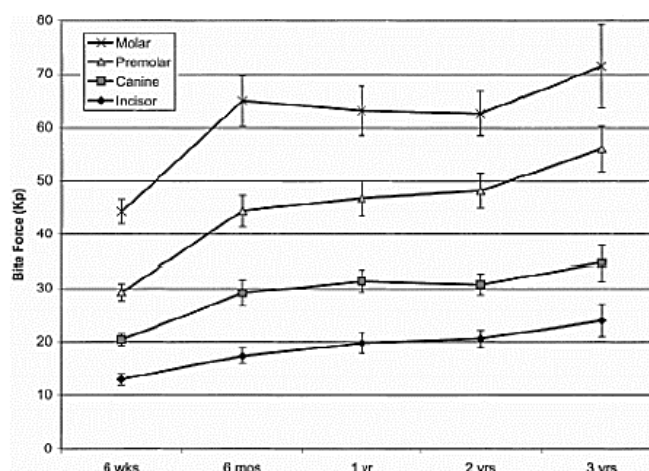
The loads applied to the facial bones, notably the maxillomandibular loads, which tend to be the most severe of all skull loads, during their normal daily activities, were transmitted to the products of the system.

In order to establish acceptance criteria, the load values (or tension, since materials fail due to tension and not due to load) that should be applied in product trials, several researchers have based themselves on in vivo studies that present bite force values, especially in the postoperative period.

In this context, Ellis and Throckmorton (2001) presented themselves as pioneers, and are frequently cited. In their study, they followed 155 patients operated on for mandibular fractures for three years after the surgery was performed. Figure 6 shows the value of the forces in kilo-pound (Kp) of bite as a function of the time elapsed after surgery in humans. The forces were measured in four different portions: molars, premolars, canines and incisors.

Figure 6

Bite after surgery



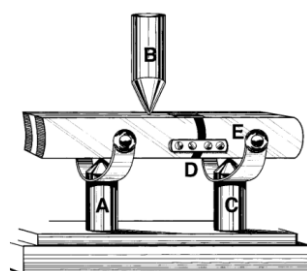
Source: Ellis, 2001.

It is noted that the curve is followed up to the third year after the surgery of the patients, reaching loads of about 70Kp. However, for the interest of this study, bite force values were observed up to a maximum of three months after surgery. This fact occurs because, according to ASTM F382, bone fractures and deformities are usually consolidated in a period of two to three months, which is the recovery phase and the use of plate/screw fixation systems, which promote the stabilization of movements and facilitate fracture consolidation. In this period, the measured loads do not reach 400N. The work of Koriath and Kannam (1994) show similar values of occlusion forces, which reach 731N in the most critical case.

In the study developed by Armstrong *et al.* (2001), five different types of internal fastening plates were mechanically tested. In this study, the authors obtained flexural strength values by varying the shapes (straight, curved, elongated) and thicknesses (0.6 and 1.0 mm) of the plates. A scheme of the assembly of the test can be seen in Figure 7.

Figure 7

3-point in vitro test, representing mandibular biomechanics



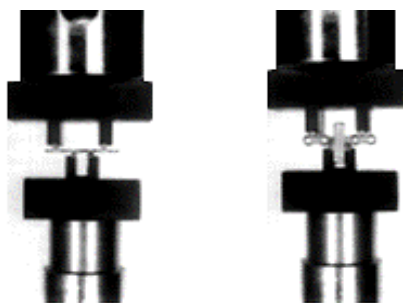
Source: Armstrong, 2001.

The values of force in the elastic limit obtained by the straight plates and elongated straight plates, both 1.0 mm thick, were 80 ± 23 N and 77 ± 19 N, respectively, according to Armstrong (2001). It should be noted that all the plates used in the study have consolidated use in the world market, as well as scientific documentation reporting several cases of clinical successes.

Following ASTM recommendations for bone plate testing, Loukota and Shelton (1995) performed frontal and lateral bending tests on six different types of plates. The assay assembly scheme can be seen in Figure 8.

Figure 8

Apparatus used in the frontal flexion (a) and lateral flexion (b) tests



Source: Loukota and Shelton, 1995.

According to Loukota and Shelton (1995), frontal and lateral flexion tests are very important, because, depending on the nature of the fracture, the orientation of the efforts can be either in one direction or the other. The authors mention that, in the anterior region of the

maxilla, for example, in LeFort osteotomies, the plates are loaded in the frontal direction, while in mandibular fixations, the plates are loaded mainly in the lateral direction. For plates made of pure titanium with 1.0 mm thickness, the maximum load values applied ranged between 70 and 125 N. For plates made of titanium with 0.85 mm thickness, the maximum load value applied was close to 60 N.

In the study by Doty *et al.* (2004), comparative trials were carried out between reconstruction plates, along with mandibles. The author found values of about 100 N for the mechanical yield limit of the assemblies tested.

The rest of the regions, such as the middle third of the face, orbits, frontalis, temple, and skull, do not exhibit appreciable stresses, since they do not perform any active movement and, even when they do, they are movements of very restricted amplitude that little or nothing deform even elastically the bones where they are anchored, and the muscles responsible for these movements.

Although all regimens are pertinent in some way, this study will consider the main one the so-called intercuspate bite (classic bite, involving the touch of all the teeth of the maxilla with those of the mandible) which is not performed in the initial recovery periods, except when the products are intended for other regions, non-mobile and not directly involved with mandibular movements. It can be argued that there will be movements from an early age due to physiotherapy, but these exercises have always been proposed and monitored by professionals in the area and generally do not involve 100% of the range of motion of any structure, in any of its degrees of freedom. This relative range is increased at a slow pace by the physiotherapist as the patient regains movement and confidence in them.

Given this initial view, it should be noted that Koriath and Kannam (1994), found for all the cases of their study, the force perpendicular to the plane of each bone studied, through Equation 1.

$$(XMI * K) * EMGMI = MIR \quad (1)$$

Where: $(XMI * K)$ is called Weight Factor and EMGMI is called Scale Factor. The multiplication of these factors leads to orthogonal force components.

Thus, it is possible to obtain the values of these forces for the main muscles involved in the intercuspate bite movement by multiplying the factors obtained by the work of Koriath and Kannam (1994). It is observed that the greatest result of this calculation was that of the superficial masseter (masticatory muscle), precisely in the intercuspate bite, and therefore, this

value of 190.4N was taken as the base value for the following calculations in the determination of the approval criteria for plaques in the regions already mentioned.

From the work of Naser-ud-Din (2009), it was possible to find numerous very representative and reliable measurements of the masseter, including the length of the superficial masseter, which is on average 56.2 mm. This measurement, when halved, gives the lever arm at which the orthogonal force found by Koriath and Kannam (1994) leads to the maximum moment involved in the intercuspals bite motion, as seen in Equation 2.

$$(Fort * L/2)/1000 = (190,4N * 28,1mm)/1000 = 5,35Nm \quad (2)$$

Where: Fort is the orthogonal force and L is the total length of the masseter. The count is divided by 1000 so that the moment in Nm is finally obtained.

From this moment value, it becomes possible to apply Equation 3.

$$\sigma = \frac{My}{I_z} \quad (3)$$

Where: σ is the final stress generated by the motion, M is the bending moment found, y is the distance to the axis of neutrality, and I_z is the moment of inertia.

Moment of inertia is a property that measures the distribution of mass of a body around an axis of rotation, and the greater the moment of inertia of a body, the more difficult it is to make it rotate. Its value and that of y depend totally on geometric factors that will belong to the mandibular ramus, a bone structure just below the superficial masseter, which is the main object of interest in this work. The calculation of I_z is given by Equation 4.

$$I_z = \frac{bh^3}{12} \quad (4)$$

Where: b is the cross-sectional length of the mandibular ramus and h its thickness.

It should be noted that y was, in this case, half of the thickness h. Its base length b can also be found in the work of Naser-ud-Din (2009), as R1-R2, which obtained a value of 29.1mm. The h-thickness was obtained in the study by Monazzi *et al.* (2010) as the average of the jaw thickness measurements of toothed cadavers, at the point defined in the work as X3, leading to a thickness h of 12.8mm, which implies a y-value of 6.4mm.

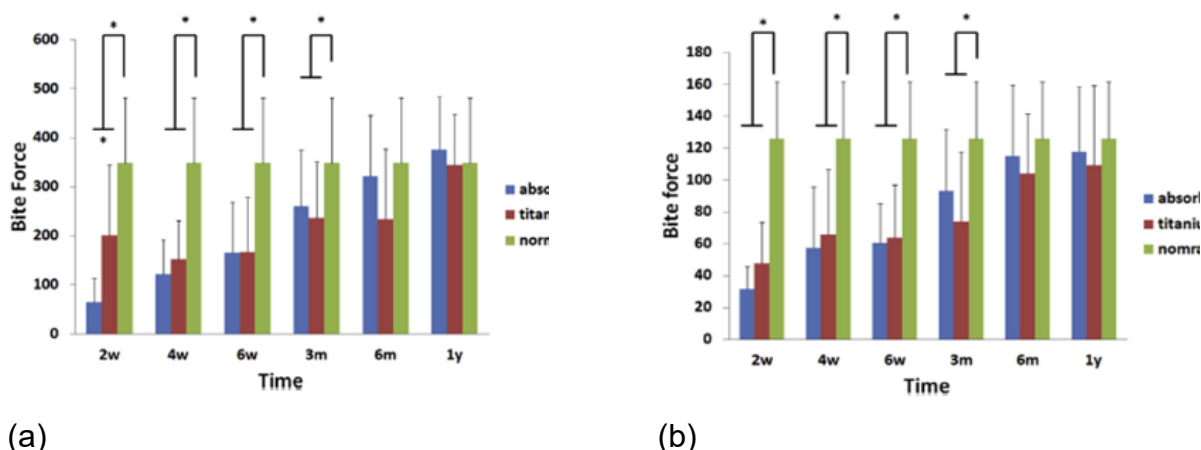
Thus, by performing the calculation of Equation 4 and subsequently the calculations of Equation 3, the stress value of 6.73MPa is obtained. It is understood that this value is then the maximum tension value, dependent on the moment, combined with geometric factors, that the superficial masseter applies, through its points of origin and insertion, on the mandibular ramus. Similarly, as the plate acts parallel to the bone and also to the muscle, it makes sense to think that the same lines of force will pass through it when the patient recovers, and the criterion of 6.73MPa is coherent, from a clinical point of view, to be used as a criterion for product validation for the region.

However, given that Koriath and Kannam (1994) arrived at a value for the occlusion force of 731N, and considering that all this charge can be transferred to the masseter by the mandible, following the same calculations presented above, a tension value of 25.8MPa is reached.

Leno (2017) studied the chewing forces after 0.5; 1,0; 1,5; 3; 6 and 12 months after surgery for fixation of jaws with the use of titanium plates, compared with normal jaws, in patients with a mean age of about 27 years. He observed that the chewing force on the molars in people with normal jaws is about 350N in the molar teeth, while for the incisor teeth this value is about 125N. For patients who used a construction plate, chewing force increased from 150N to 350N in one year for molar teeth, and from 50N to 125N for incisor teeth. Figure 9 shows these values obtained.

Figure 9

Mastication force for a) molar teeth and b) incisors



Source: Leno, 2017.

The work of Coskunes (2015) studied by simulation the resulting stresses in plates when loading 250N in the molars, and 125N in the incisors, being about 800MPa and 400MPa, respectively. However, for some charging conditions, the calculated voltage was

even higher, above 1,000MPa. These values are higher than the yield stress values of titanium ranging from 170 to 483MPa, according to ASTM F67. These values are overestimated, given that they are masticatory load values for a normal maxilla and, according to Leno (2017), the initial postoperative loads are much lower, from 50N to 150N.

Even so, other studies, such as that of Palka (2021) and Huang (2016) also simulated occlusal loads of about 150N and obtained plate stresses of the order of 500MPa to 1,000MPa.

This implies that, in fact, the load to be released to the patient in the first weeks was thought by the surgeon as a function of the number of plates installed, the level of fracture reduction, or the displacement imposed by orthognathic surgery.

3.3 ACCEPTANCE CRITERIA FOR SCREWS

Although the annulled screws do not fit the dimensional requirements of any Brazilian or international standard, and in the absence of a better objective criterion, the screws were evaluated according to the ABNT NBR 15675/1 (2022) standard - Orthopedic implants - Metal bone screws - Part 1: Requirements, which establishes torque and rupture angle values as acceptance criteria for non-corrugated screws.

The acceptance criteria for the rupture torque are based on the internal diameter, that is, it is defined as:

$$T_{\max} = 0,157.(\varnothing_{\text{int}})^3 \quad (5)$$

Where: Tmax is the maximum torque to be achieved as a criterion and $\varnothing_{\text{int}}$ is the inner diameter of the bolt (web). Table 9 shows the values required as a criterion as a function of the internal diameter.

Table 9

Values required as a criterion as a function of internal diameter

Code	Description	$\varnothing_{\text{ext}}$	$\varnothing_{\text{int}}$	Criterion (Nm)
PFSC16.10	Piercing screw 1.6mm	1,6	1,1	0,21
PFSC19.10	Piercing screw 1.9mm	1,9	1,1	0,21
PFSC21.10	Piercing screw 2.1mm	2,1	1,2	0,27
PFSC24.10	2.4mm piercing screw	2,4	1,5	0,53

Source: Authors, 2023.

For the rupture angle, ABNT NBR 15675/1 (2022), establishes that the criterion must be calculated as a function of the relationship between the external and internal diameters and a geometric coefficient:

$$A = \frac{\alpha \times L_e}{\varnothing_{int}} \quad (6)$$

Where α is the geometric coefficient $\varnothing_{ext}/\varnothing_{int}$ of Figure 10, while the values of the angle of rupture are described in Figure 10. The L_e value is the length referring to the number of threads exposed in the test, pitch * number of threads, $\varnothing_{ext}$ – outer diameter and $\varnothing_{int}$ – inner diameter.

Figure 10

Geometric coefficient as a function of the relationship between $\varnothing_{ext}/\varnothing_{int}$

Modelo	Relação $\frac{\varnothing_{ext}}{\varnothing_{int}}$	Coefficiente geométrico α graus
Rosca rasa	$\frac{\varnothing_{ext}}{\varnothing_{int}} \leq 1,60$	62
Rosca intermediária	$1,60 < \frac{\varnothing_{ext}}{\varnothing_{int}} < 2,00$	41
Rosca profunda	$\frac{\varnothing_{ext}}{\varnothing_{int}} \geq 2,00$	20

Source: NBR 15675/1, 2022.

Additionally, the ABNT NBR 15675 standard requires that insertion tests be compared to the yield torque, given that, if they deform plastically, this constitutes an adverse event, and the product was explanted, May (2014).

Table 10

Required d-values and angle of rupture for the screws

Code	Description (Screw)	Øext	Øint	Step	fillets	Øext / Øint	α	Criteria α.Lo/Øint
PFSC16.10	perforating 1.6mm	1,6	1,1	0,60	5	1,45	$\frac{6}{2}$	237
PFSC19.10	perforating 1.9mm	1,9	1,1	0,60	5	1,73	$\frac{4}{1}$	157
PFSC21.10	perforating 2.1mm	2,1	1,2	1,00	5	1,75	$\frac{4}{1}$	171
PFSC24.10	piercing 2.4mm	2,4	1,5	1,00	5	1,60	$\frac{6}{2}$	207
PFSC25.10	piercing 2.5mm	2,5	1,6	1,00	5	1,56	$\frac{6}{2}$	194
PFSC28.10	perforating 2.8mm	2,5	1,9	1,00	5	1,32	$\frac{6}{2}$	163

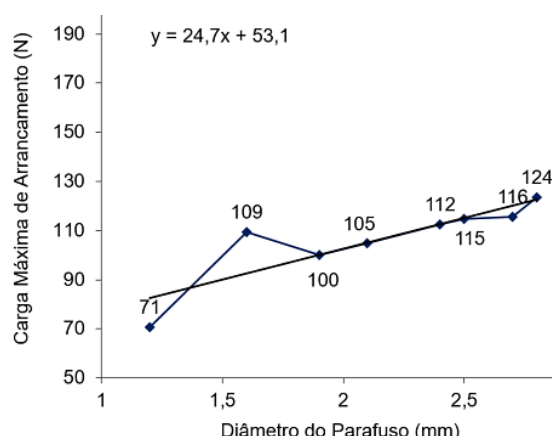
Source: Authors, 2023.

Due to the lack of specification of values to be taken as approval criteria, the difficulty of establishing a clear rule is evidenced, since, from the point of view of use, the quality of the patient's bone varies from case to case. Evidence of this is the statements of Loffredo (2007), in which bones are part of an arrangement that supports a structure, and therefore, have their own mechanical properties for each type of request required by the human body. Thus, parameters such as age, sex, ethnicity, interfere with and vary human bone properties. It is therefore up to the development area of each company to define its own approval criteria. In this way, the company takes literature values as a basis and adopts them as an approval criterion. It should be noted that the literature on assay values in human bones is scarce.

A scientific methodology was used to identify values to be taken as approval criteria in the absence of similar data. Even though this article by Gausepohl *et al.* (2001), unique in the evaluation of several products, it does not include all possible diameters. Thus, a linear regression is possible to construct, and to obtain values that have not been effectively tested, but that are part of the range of products available in the market. Figure 11 shows the values obtained by extrapolation of a linear regression (indicated in black) from the original data of the article by Gausepohl *et al.* (2001), (indicated in blue). These values (in blue and black) can be taken as an approval criterion for products with their respective diameters.

Figure 11

Maximum pullout load according to screw diameter



Source: Modified from Gausepohl *et al.* (2001).

Thus, values that the literature indicates as a reference for this trial were used. Thus, according to the work of Gausepohl *et al.* (2001), a comparative study of the pullout force of cortical and cancellous screws shows that, for cortical screws of 1.2; 1.6 and 2.7 mm in outer diameter, the maximum pullout forces are up to 71, 109 and 116N, respectively (**Figure 11**). Doing a linear regression to screw of 1.9; 2.1; 2.5 and 2.8mm have a maximum pullout load value of 100, 105, 115 and 124N, respectively.

Table 11 shows a pullout study performed with 1.7 mm Stryker screws. It is observed that depending on the region of insertion in the bone of the human cadaver, the pullout resistance can vary from about 32N to 182N for the unicortical installation.

Table 11

Pullout force, in Newton, for 1.7mm screw

	Unicortical	Bicortical α	p-value
Proximal metaphyses	31,5 (16,9)	103,3 (6,0)	<0.005
Mid diaphyses	181,8 (33,7)	333,8 (31,4)	<0.005
Distal metaphyses	64,9 (21,6)	171,8 (17,1)	<0.005

Source: Khalid *et al.* (2008).

Regarding the insertion/removal torque, May (2014) shows that torques should not be higher than the yield torque, given that permanent plastic deformation reduces the fatigue life of the product, and is configured as an adverse event, and the product should be explanted by the surgeon.

Thus, in order to highlight the safety and efficacy of the product, torsion and pullout tests were carried out for the screws.

3.4 RESULTS FOR SCREWS

The lowest values obtained in tests were taken, since the sampling of 5 specimens required in the standard is not statistically representative, and compared to the values required in the standard.

Table 12 presents the results of the pull-out test carried out in accordance with the ABNT 15675/1 (2022) standard and shows the approval criterion according to the extrapolation analysis of the maximum pull-out load, based on Gausepohl *et al.* (2001).

Table 12

Results of the screw pullout test

Code	Description	Øext (mm)	Start. (N)	Criterion (N)*	Report
PFSC16.10	Piercing screw 1.6mm	1,6	378,4	371,16	1234
PFSC19.10	Piercing screw 1.9mm	1,9	383,2	388,19	2345
PFSC21.10	Piercing screw 2.1mm	2,1	377,9	349,81	3456
PFSC24.10	2.4mm piercing screw	2,4	390,1	387,40	4567

Source: Company X, 2022.

The results obtained in this test method are not intended to predict the force required to remove a screw from human or animal bone. This method is intended only to measure the uniformity of the products tested, or to compare the strength of different products.

It is observed that the maximum pullout force is much higher than the product approval criterion, ensuring its safety. Table 13 presents the results of the torsion test of the screws that are the object of this research, and presents as an approval criterion the reference values of the NBR 15675/2 (2018) standard.

Table 13

Results of the torsion test of the screws

Code	Description	*Trup (Nm)	Criterion (Nm)	Report
PFSC16.10	Piercing screw 1.6mm	0,35	0,21	1234
PFSC19.10	Piercing screw 1.9mm	0,30	0,21	2345
PFSC21.10	Piercing screw 2.1mm	0,44	0,27	3456
PFSC24.10	2.4mm piercing screw	0,58	0,53	4567

*Trup = Breakdown Voltage

Source: Company X, 2022.

The results of the torsion test show that the breaking torque and failure angle meet the adopted acceptance criteria. Table 14 shows the results recorded for the angle of rupture.

Table 14

Results obtained for the rupture angle

Code	Description	*Arup(°)	Criterion	Report
PFSC16.10	Piercing screw 1.6mm	240,0	237	1234
PFSC19.10	Piercing screw 1.9mm	249,2	157	2345
PFSC21.10	Piercing screw 2.1mm	224,3	171	3456
PFSC24.10	2.4mm piercing screw	232,2	207	4567

*Arup=Angle of Rupture

Source: Company X, 2022.

It is observed that the values of the rupture angle recorded for the products meet the acceptance criteria required by the NBR 15675/2 (2018) standard. Table 15 shows that the insertion torque does not reach the yield torque, so that the screw will not deform or rupture during insertion.

Table 15

Values obtained for the insertion/removal torque

Code	Description (""')	**Ins/Rem (Nm)	Criterion (Nm)*	Report
PFSC16.10	perforating 1.6mm	0,1384	0,10	1234
PFSC19.10	perforating 1.9mm	0,1387	0,10	2345
PFSC21.10	perforating 2.1mm	0,1487	0,10	3456
PFSC24.10	piercing 2.4mm	0,1429	0,10	4567

* criterion: yield torque obtained for the bolts / **Ins/Rem=Insertion and Removal

Source: Company X, 2022.

3.5 RESULT FOR PLATES

Table 16 shows the results for the static tests according to ASTM F382.

Table 16

Results obtained for static tests according to ASTM F382.

Code	Description	Thickness (mm)	Width (mm)	$I_z = \frac{B \cdot H^3}{12}$	F (N)	M (Nm) static	$\sigma(MPa) = \frac{M \cdot y}{I_z}$ Static	Static Criterion (MPa)	Static Report
1234	Rectilinear Microplate 20 Holes	0,63	2	0,064	9,1	0,057	356	25,8	5087-16
2345	Left Microplate Advance 13mm	0,63	2	0,167	15,2	0,096	288	25,8	5086-15
3456	Mini Straight Plate 20 Holes	1	3	0,021	12,4	0,25	3000	25,8	4049-15
4567	Mini Left Plate	1	3	0,021	14,6	0,033	396	25,8	3359-15

Advance
13mm

Source: Company X, 2022.

It is observed that the results obtained are superior to the acceptance criterion adopted. Table 17 shows the results for the dynamic tests according to ASTM F382.

Table 17

Results obtained for dynamic tests according to ASTM F382.

Code	Description	Thickness (mm)	Width (mm)	Iz= B*H ³ /12	Strength (N)	M (Nm) static	$\sigma(\text{MPa})=M*Y/Iz$ Static	Static Criterion (MPa)	Static Report
1234	Rectilinear Microplate 20 Holes	0,7	2,2	0,063	2,5	0,025	139	25,8	0151- 15
2345	Left Microplate Advance 13mm	0,8	1,5	0,064	6,9	0,043	269	25,8	5088- 16
3456	Mini Straight Plate 20 Holes	0,5	2	0,021	17,1	0,034	408	25,8	4050- 15
4567	Mini Left Plate Advance 13mm	0,5	2	0,021	13,7	0,031	372	25,8	3360- 15

Source: Company X, 2022.

Thus, from the analysis of the results, considering the normal daily loads involved for its region of indication, it was possible to develop criteria consistent with the application of the product. These criteria were used in comparison with the results obtained in the mechanical tests, as well as with the results obtained for the predicate devices. It was observed that all plates presented resistance values higher than the biomechanical acceptance criterion. It is also observed that the resistance voltage values are similar to the predicate devices registered with ANVISA and marketed in Brazil. Thus, the results presented for the plates are adequate to the components evaluated, meeting the approval criteria, which guarantees the safety and efficacy of the products under study.

4 CONCLUSION

The results presented in the scientific literature, clinical studies, and data obtained from mechanical tests carried out on the products under study, substantiate the safety and efficacy of the system for the indicated and intended use. Thus, it is concluded that, if the system is used according to the indicated and intended use, the clinical benefits for the patient outweigh the possible risks of using the product.

REFERENCES

- Armstrong, J. E., et al. (2001). Preliminary investigation of the biomechanics of internal fixation of sagittal split osteotomies with miniplates using a newly designed in vitro testing model. *Journal of Oral and Maxillofacial Surgery*, 59, 191–195.
- Associação Brasileira de Normas Técnicas. (2001). NBR ISO 5832-2: Implantes para cirurgia – Materiais metálicos – Parte 2: Titânio puro.
- Associação Brasileira de Normas Técnicas. (2018). NBR 15675-2: Implantes para ortopedia – Parafusos ósseos metálicos – Parte 2: Determinação das propriedades de torção.
- Associação Brasileira de Normas Técnicas. (2022). NBR 15675-1: Implantes para ortopedia – Parafusos ósseos metálicos – Parte 1: Requisitos.
- ASTM International. (2013). ASTM E8/E8M-11: Standard test methods for tension testing of metallic materials.
- ASTM International. (2017). ASTM F382: Standard specification and test method for metallic bone plates.
- ASTM International. (2017). ASTM F67-06: Standard specification for unalloyed titanium for surgical implant applications.
- ASTM International. (2021). ASTM F136-11: Standard specification for wrought titanium-6Aluminum-4Vanadium ELI alloy for surgical implant applications.
- ASTM International. (2021). ASTM F1839-08: Standard specification for rigid polyurethane foam for use as a standard material for testing orthopedic devices and instruments.
- ASTM International. (2023). ASTM F543: Standard specification and test methods for metallic medical bone screws.
- Brånemark, P. I., et al. (1977). Osseo integrated implants in the treatment of the edentulous jaw: Experience from a 10-year period. *Scandinavian Journal of Plastic and Reconstructive Surgery*, 16, 1–132.
- Coskunses, F. M. (2015). Evaluation of prebent miniplates in fixation of Le Fort I advancement osteotomy with the finite element method. *Journal of Cranio-Maxillo-Facial Surgery*, 43, 1505–1510.
- Currey, J. D. (2006). *Bones: Structure and mechanics*. Princeton University Press.
- Doty, J. M., et al. (2004). Biomechanical evaluation of fixation techniques for bridging segmental mandible defects. *Archives of Otolaryngology–Head & Neck Surgery*, 130, 1388–1392.
- Dunlop, J. W. C., & Fratzl, P. (2010). Biological composites. *Annual Review of Materials Research*, 40, 1–24.
- Ellis, E., & Throckmorton, G. S. (2001). Bite forces after open or closed treatment of mandible condylar process fractures. *Journal of Oral and Maxillofacial Surgery*, 59, 389–395.

- Gausepohl, T., et al. (2001). Fine thread versus coarse thread: A comparison of the maximal holding power. *Injury*, 32, S-D1–S-D7.
- Huang, S. F. (2016). Biomechanical optimization of a custom-made positioning and fixing bone plate for Le Fort I osteotomy by finite element analysis. *Computers in Biology and Medicine*, 68, 49–56.
- Junqueira, L. C., & Carneiro, J. (2017). *Histologia básica* (13^a ed.). Guanabara Koogan.
- Karam, F. C., & Lopes, M. H. I. (2005). Ortopedia: origem histórica, o ensino no Brasil e estudos metodológicos pelo mundo. *Scientia Medica*, 15(3), 172–178.
- Khalid, M., et al. (2008). Biomechanical comparison of pull-out force of unicortical versus bicortical screws in proximal phalanges of the hand: A human cadaveric study. *Clinical Biomechanics*, 23, 1136–1140.
- Korioth, T. W. P., & Hannam, A. G. (1994). Mandible forces during simulated tooth clenching. *Journal of Orofacial Pain*, 8, 178–189.
- Lazow, S. K., & Tarlo, I. (2009). Mandible fracture: transoral 2.0-mm locking miniplate plus 1-week maxillomandibular fixation. *Atlas of the Oral and Maxillofacial Surgery Clinics of North America*, 17(1), 27–34.
- Leno, M. B. (2017). Comparison of functional outcomes and patient-reported satisfaction between titanium and absorbable plates and screws for fixation of mandibular fractures: A one-year prospective study. *Journal of Cranio-Maxillo-Facial Surgery*, 45, 704–709.
- Loffredo, M. C. M., et al. (2007). Resistência mecânica e tenacidade à fratura do osso cortical bovino. *Revista Brasileira de Engenharia Biomédica*, 23(2), 159–168.
- Loukota, R. A., & Shelton, J. C. (1995). Mechanical analysis of maxillofacial miniplates. *British Journal of Oral and Maxillofacial Surgery*, 33, 174–179.
- May, J. E., et al. (2014a). Correlation between rupture and yield torques in orthopedic screws. *Revista Eletrônica de Materiais e Processos*, 9(1), 45–50.
- May, J. E., et al. (2014b). Physiological bone loading in the human head and prosthesis size estimation. *International Journal of Engineering & Technology*, 14(1).
- Meyer, C., et al. (2002). Photoelastic analysis of bone deformation in the region of the mandibular condyle during mastication. *Journal of Cranio-Maxillofacial Surgery*, 30(3), 160–169.
- Monazzi, M. S., et al. (2010). Avaliação da espessura da mandíbula com relação à fixação interna rígida em osteotomia sagital. *Revista Brasileira de Cirurgia Bucomaxilofacial*, 10, 43–48.
- Naser-ud-Din, S. (2009). Analysis and correlation study of human masseter muscle with EMG, ultrasonography & 3D imaging (PhD thesis). The University of Adelaide.
- Palka, L. (2021). Analysis using the finite element method of a novel modular system of additively manufactured osteofixation plates for mandibular fractures – A preclinical study. *Biomedical Signal Processing and Control*, 65.

- Ramos, J. C., et al. (2018). Estudo epidemiológico do trauma bucomaxilofacial em um hospital de referência da Paraíba. *Revista do Colégio Brasileiro de Cirurgiões*, 45.
- Vivacqua, C. F. P. P., & Elias, C. N. (2012). Propriedades mecânicas em flexão do osso cortical bovino. *Revista Militar de Ciência e Tecnologia*, 24.

ÁCIDO FOSFÓRICO: UM PROBLEMA PARA PACIENTES ODONTOPEDIÁTRICOS

ÁCIDO FOSFÓRICO: UN PROBLEMA PARA LOS PACIENTES PEDIÁTRICOS DE ODONTOLOGÍA.



10.56238/sevened2026.021-006

Alice da Silva Alencar¹, Rusbene Bruno Fonseca de Carvalho², Marcos Vinícios Alves de Sa³, Lina Clara Gayoso e Almendra Ibiapina Moreno⁴, Thaís Cruz Ramalho⁵, Layreson Teylon Silva Fernandes de Sousa⁶, Hercília Maria Lins Rolim⁷

ABSTRACT

Phosphoric acid at 37% is widely used in restorative dentistry as an etching agent, promoting the adhesion of materials to enamel and dentin. However, its intensely acidic taste poses a challenge in pediatric dental care, potentially affecting children's acceptance and compromising their cooperation during clinical procedures. This study aimed to review recent scientific literature on the sensory impacts of phosphoric acid in pediatric patients and discuss alternatives to make its use more tolerable. A total of 34 articles from the Scielo, MEDLINE, Lilacs, Scopus e Web of Science were analyzed, of which 11 were selected after applying exclusion criteria. The data indicate that modifying the formulation of phosphoric acid by adding flavor-masking agents can significantly improve the pediatric patient's experience without compromising its clinical effectiveness. It is concluded that reformulating the product represents a promising strategy to enhance comfort and adherence to dental treatment in children, although further research is needed to enable its clinical application.

Keywords: Permanent Dental Restoration. Acid Etching of the Tooth. Flavor Enhancers.

¹ Master's in Biotechnology in Human and Animal Health. Universidade Estadual do Ceará (UECE). E-mail: alice_alencar@outlook.com Orcid: <https://orcid.org/0009-0002-3767-7536>

Lattes: <https://lattes.cnpq.br/4135578649155243>

² PhD in Biotechnology (RENORBIO). Universidade Federal do Piauí (UFPI). E-mail: rusbenecarvalho@gmail.com Orcid: <https://orcid.org/0000-0002-5993-1729>

Lattes: <http://lattes.cnpq.br/2243362623573208>

³ Degree in Biological Sciences. Universidade Estadual do Maranhão. Orcid: <https://orcid.org/0000-0001-5072-1242> Lattes: <http://lattes.cnpq.br/2637231335051593>

⁴ Postdoctorate in Pharmacy and Pharmaceutical Technology. Universidade Federal do Piauí. E-mail: linaclaramoreno@gmail.com Orcid: 0000-0001-7244-7977

Lattes: <https://lattes.cnpq.br/9742603879957424>

⁵ PhD in Pharmaceutical Sciences. Universidade Federal do Piauí. E-mail: thaiscramalho@gmail.com Orcid: <https://orcid.org/0000-0002-1117-5100> Lattes: <http://lattes.cnpq.br/6059695116735885>

⁶ Master's student in Biotechnology in Human and Animal Health. Universidade Estadual do Ceará (UECE). E-mail: teylon_10@hotmail.com Orcid: <https://orcid.org/0000-0002-6501-7335>

Lattes: <https://lattes.cnpq.br/6287118459710544>

⁷ PhD in Biological Sciences. Universidade Federal de Pernambuco (UFPE). E-mail: hercilia.rolim@gmail.com Orcid: <https://orcid.org/0009-0003-9759-9688> Lattes: <http://lattes.cnpq.br/5358149065349859>

RESUMO

O ácido fosfórico a 37% é amplamente utilizado na odontologia restauradora como agente condicionante, favorecendo a adesão de materiais ao esmalte e à dentina. No entanto, seu sabor intensamente ácido representa um desafio no atendimento odontopediátrico, podendo interferir na aceitação por parte da criança e comprometendo sua colaboração durante o procedimento clínico. Este estudo teve como objetivo revisar a literatura científica recente sobre os impactos sensoriais do ácido fosfórico em pacientes pediátricos e discutir alternativas para tornar seu uso mais tolerável. Foram analisados 34 artigos provenientes das bases Scielo, MEDLINE, Lilacs, Scopus e Web of Science, dos quais 11 foram selecionados após a aplicação de critérios de exclusão. Os dados indicam que a modificação da formulação do ácido fosfórico, por meio da adição de flavorizantes, pode melhorar significativamente a experiência do paciente infantil, sem comprometer à sua eficácia clínica. Conclui-se que a reformulação do produto configura uma estratégia promissora para ampliar o conforto e a adesão ao tratamento odontológico em crianças, embora sejam necessárias investigações adicionais para viabilizar sua aplicação clínica.

Palavras-chave: Restauração Dentária Permanente. Condicionamento Ácido do Dente. Realçadores de Sabor.

RESUMEN

El ácido fosfórico al 37% se utiliza ampliamente en odontología restauradora como agente acondicionador, promoviendo la adhesión de materiales al esmalte y la dentina. Sin embargo, su sabor intensamente ácido representa un desafío en la atención odontológica pediátrica, ya que puede interferir con la aceptación del niño y comprometer su cooperación durante el procedimiento clínico. Este estudio tuvo como objetivo revisar la literatura científica reciente sobre los efectos sensoriales del ácido fosfórico en pacientes pediátricos y analizar alternativas para mejorar su tolerancia. Se analizaron treinta y cuatro artículos de las bases de datos Scielo, MEDLINE, Lilacs, Scopus y Web of Science, de los cuales se seleccionaron 11 tras aplicar criterios de exclusión. Los datos indican que modificar la formulación del ácido fosfórico mediante la adición de saborizantes puede mejorar significativamente la experiencia del paciente infantil sin comprometer su eficacia clínica. En conclusión, reformular el producto representa una estrategia prometedora para aumentar la comodidad y la adherencia al tratamiento dental en niños, aunque se requiere más investigación para determinar su aplicabilidad clínica.

Palabras clave: Restauración Dental Permanente. Grabado Ácido del Diente. Potenciadores del Sabor.

1 INTRODUCTION

Adherence to dental treatment by pediatric patients represents a significant challenge, especially when it involves the use of substances with unpleasant sensory characteristics (Oliveira, *et al.* 2024). Phosphoric acid is widely used in dentistry for the acid etching of dental enamel, favouring the adhesion of restorative materials. However, its acidic and aversive taste may hinder its acceptance by children, impacting the clinical experience and the cooperation of patients during the procedure (Gonçalves *et al.*, 2019).

In view of this problem, this study proposes a review of innovative strategies applied to phosphoric acid through flavouring agents, based on the topic explored by Medeiros & Garruti (2018), which demonstrated improvements in the acceptability of the product by pediatric dental patients, promoting an approach that combines functional efficacy and sensory comfort, providing a friendlier and more collaborative approach in care.

Finally, the work is structured as follows: initially, regarding the use of the acid, the importance of this product in dentistry will be explained and the challenges of this dental product will be presented. Next, the importance of flavourings in industry and during dental care. Subsequently, the innovative potential of the use of flavourings in dentistry will be addressed. Concluding, the results and discussions will be presented, followed by the final considerations on the feasibility of the proposal.

With the aim of masking these aversive sensory attributes, flavourings may be incorporated into the formulation of phosphoric acid in order to soften the bitter taste, which could be the differential of this market, facilitating its use by the general public, especially in the pediatric dental population which most demands an improvement in the taste of this product, as well as maintaining the physicochemical properties and stability of this composition.

1.1 USE OF PHOSPHORIC ACID

Many studies have investigated and proven the efficacy of phosphoric acid, acting in various ways in the removal of the smear layer. The presence of the acid directly on the tooth generates a superficial demineralisation, as well as the creation of pores to facilitate the adhesion and fixation of the restorative material, in addition to activating proteolytic enzymes that degenerate the hybrid layer (Oliveira, *et al.*, 2024). This demonstrates the great versatility of this product, which is still indispensable in the clinical life of Dental Surgeons.

On this basis, phosphoric acid at 35-40% in the form of a liquid or gel is frequently used for chemical treatment, the acid etching of hard dental tissue, enamel or dentin (Sakaguchi & Powers, 2012). This etching removes the smear layer and generates a

relatively rough surface to produce a better interface on which the application of bonding agents will take place (Plá *et al.*, 2016).

However, in the event of accidental exposure to large quantities, this acid can generate negative effects on soft tissues and the periodontium, even if excess acid is removed with cotton rolls or gauze; the rinsing of the remainder may cause an unpleasant and bitter taste to the patient's palate, who frequently reports dissatisfaction (Gonçalves *et al.*, 2019).

As previously explained, phosphoric acid acts in the performance of dental restorations; thus, the ideal restorative material would be one capable of establishing a chemical bond with the dental tissue and presenting mechanical resistance similar to that of the dental structure. Dental enamel is composed, for the most part, of approximately 95% mineral material. This rigid tissue, when intact, does not favour the effective adhesion of adhesive systems, since its smooth surface results in low surface energy (Alves, W. P., 2026).

To enable the diffusion of resin monomers, acid etching acts by dissolving the enamel prisms and the interprismatic region, originating a porous microstructure that facilitates the subsequent penetration of the restorative material. The generation of this retentive surface, conducive to the interpenetration of fluid resins or low-viscosity composites, provides an effective adhesion to this substrate (Parihar; Pilania, 2012). The acid has an indispensable function in the performance of dental restorations; however, due to the unpleasant taste, the acid formulation found on the market still requires improvement, and one market strategy is the use of flavourings with the proposal of mitigating the problem.

2.1 ROLE OF FLAVOURINGS

Aversion to undesirable tastes is a physiological response. From an evolutionary perspective, the senses responsible for evaluating what is placed in the oral cavity developed to reject what is harmful and seek what is beneficial. The more bitter and irritating the taste, the greater the probability of rejection (Medeiros & Garruti, 2018). Sensory analysis is a useful apparatus for obtaining products that are not only safe and effective, but also acceptable to consumers, and the softening of the taste of the materials used may be a market differential (Gonçalves *et al.*, 2019).

Phosphoric acid (INS 338) demonstrates the highest acidity among all the acids employed in beverages. Its application is predominant in cola-type soft drinks (Medeiros & Garruti, 2018), being a product used abundantly in the food industry.

The development of formulations with the use of suitable excipients, such as the addition of an aromatising agent to the acid etching gel with the function of masking the unpleasant sensory characteristics in accidental situations of exposure to phosphoric acid;

that is, the inclusion of the aromatiser is not intended to encourage the consumption of the product, but rather to promote its adaptation and acceptability in the face of possible unforeseen events during the procedures (Reinol, 2014). In this context, in addition to reducing the discomfort of adult patients, it could minimise problems in pediatric dental care, occasionally encountered when children come into contact with the acid gel (Gonçalves *et al.*, 2019).

2.2 INNOVATIVE POTENTIAL

Various researchers have endeavoured to search for low-cost materials with the aim of enabling the development of new products. As demonstrated in reviews of previously published studies (Reinol, 2014).

In earlier periods, the production and supply of food occurred predominantly in regions geographically close to their place of consumption. However, with the impacts of globalisation and the improvement of logistics systems at national and international levels, the transport of food originating from distant areas has become recurrent. In this context, the use of additives and preservatives becomes necessary to ensure the stability, safety and integrity of the products throughout the distribution chain (Honorato *et al.*, 2013).

Likewise, we can take as a basis, among the dental products used as topical anaesthetics available on the market, benzocaine at 20%, which stands out as the most widely employed substance globally. Chemically classified as an ester, it is presented predominantly in gel form. Due to its rapid onset of action and its unmistakable Tutti-frutti smell, it has become extensively accepted by children at the moment of surgeries (Bastos *et al.*, 2020).

However, phosphoric acid at 37%, which is also widely used as an etching agent in restorative procedures, presents an intensely acidic and unpleasant taste, frequently reported by patients as a factor of discomfort during dental care. This characteristic taste can be especially bothersome in prolonged appointments or in pediatric patients, in whom gustatory sensitivity is more pronounced (Gonçalves *et al.*, 2019). In addition to compromising the patient's experience, aversion to the taste can hinder cooperation during the clinical procedure, negatively impacting adherence to treatment. Thus, the search for strategies that minimise this sensory effect, such as the incorporation of flavouring agents, proves to be relevant for improving the acceptance of the material and comfort during dental care (Bastos *et al.*, 2020).

2 MATERIAL AND METHODS

The development of this work was based on articles, accessed through databases such as Scielo, MEDLINE, Lilacs, Scopus and Web of Science, published between 2012 and 2026. The descriptors used were: “Restauração Dentária Permanente”, “Condicionamento ácido do dente”, “Realçadores de sabor”, as well as their English correspondents: “Permanent Dental Restoration”, “Acid Etching of the Tooth” and “Flavor Enhancers”.

The exclusion criteria of this study included research not directly linked to the topic and publications prior to 2012, as well as those written in languages other than Portuguese or English. The selected works were chosen based on their relevance and alignment with the objective of this study, with relevant characteristics such as pertinence to the topic, type of study, availability of the full text, methodological quality and scientific relevance. Thus, any descriptors that did not fit the main focus of the construct were disregarded, discarding materials whose keywords or contents deviated from the purpose of this work.

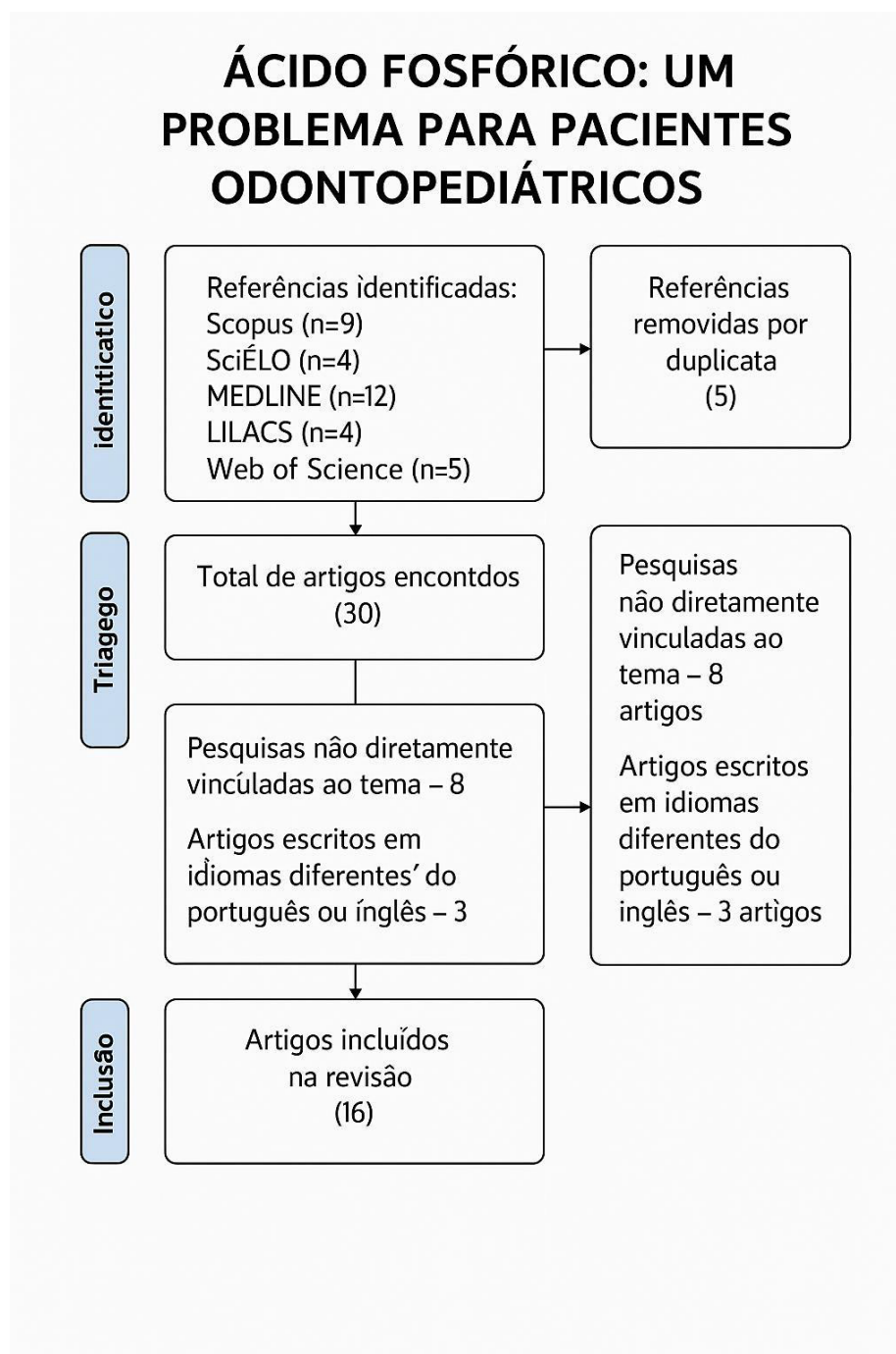
3 RESULTS AND DISCUSSIONS

From the searches carried out in the databases, a total of 34 articles related to the proposed theme were obtained. After the removal of duplicates ($n=6$), 28 studies remained for screening. Table 1 shows a summary of the stage of analysis of the abstracts and titles; 9 articles were excluded for not being directly related to the topic, 4 for being published before 2012 and 3 for being written in languages other than Portuguese and English, resulting in 16 exclusions.

Thus, 12 studies were included for full reading. After this stage, 1 article was eliminated for not meeting the established methodological criteria, with 11 then being the articles selected to compose the present review. An overview of the 11 articles included in this study is presented in Table 2.

Table 1

Map of the methodology for selecting the review articles



Source: prepared by the authors, 2026.

Table 2

Brief description of the articles selected for the review

Title	Author/Year	Research Objective	Methodology	Main Results	Contribution to the Theme
Sign glossary in LIBRAS in restorative	Alves, W. P., 2026	To develop a sign glossary in LIBRAS for	Master's dissertation with development and	Specific sign glossary that facilitates	Increases accessibility and inclusion in

dentistry for the inclusion of the deaf in dentistry		restorative dentistry aiming at the inclusion of the deaf	qualitative analysis	communication in dentistry for the deaf	dental practice, as well as knowledge about restorative dentistry
Sensory effects of conditioning agents modified with flavourings in pediatric dentistry	Cardoso <i>et al.</i> , 2021	To evaluate the sensory effects of conditioning agents with flavourings for children	Experimental study and sensory analysis	Flavourings improved acceptability without compromising efficacy	Improves adherence to treatment in pediatric dentistry
Modification and evaluation of 35% phosphoric acid gel with an aromatising agent	Gonçalves <i>et al.</i> , 2019	To modify phosphoric acid gel with aromatisers and evaluate properties	Experimental study with physicochemical tests	Aromatisers improved acceptability and maintained efficacy	Development of dental products more accepted by patients
Adhesive systems for restoring primary teeth: a systematic review and meta-analysis of in vitro studies	Lenzi <i>et al.</i> , 2016	To evaluate adhesive systems for restorations in primary teeth	Systematic review and meta-analysis	Identification of the systems with the best performance	Support for the choice of adhesives in pediatric dentistry, and improvement of restorations
Studies on the palatability of medicines: sensory analysis and acceptability of pediatric formulations	Medeiros & Garruti, 2018	To evaluate the sensory acceptance of pediatric formulations	Experimental study with sensory tests	Identification of the attributes that influence acceptance	Essential for the development of pediatric products
Influence of the use of glycolic acid and universal adhesives on the quality of the hybrid layer	Oliveira <i>et al.</i> , 2024	To review the effects of glycolic acid and universal adhesives on the quality of the hybrid layer	Literature review	Combined use improves the quality and resistance of the hybrid layer, which is the zone of micromechanical bonding between the tooth and the restorative material	Improvement of restorative techniques and enhancement of the durability of restorations
Scanning electron microscopy (SEM) evaluation of the effect of 37% phosphoric acid gel, 24% EDTA gel and 10% maleic acid gel on enamel and dentin during 15 and	Parihar & Pilania, 2012	To evaluate the effect of phosphoric acid, EDTA and maleic acid gel on enamel and dentin	In vitro study with scanning electron microscopy (SEM)	Different morphological effects and application time influence the result	Optimisation of dental etching protocols

60 seconds: an in vitro study.					
Thirteen-year randomized controlled clinical trial of a two-step self-etch adhesive in noncarious cervical lesions.	Peumans <i>et al.</i> , 2015	To evaluate the long-term performance of a self-etch adhesive in noncarious cervical lesions.	Randomized clinical trial	High survival and stability of the adhesive	Confirms the efficacy of modern adhesives in clinical treatments, after an effective acid attack for the application of this adhesive
Evaluation of phosphoric acid gel with an aromatising agent	Plá <i>et al.</i> , 2016	To evaluate the physicochemical and sensory properties of phosphoric gel with an aromatiser	Experimental and sensory study	Aromatiser improves taste without compromising properties	Development of dental products more accepted
Palatability of chloral hydrate-based pediatric pharmaceutical formulations	Reinol, F. C., 2014	To evaluate the acceptance of pediatric medicinal formulations with chloral hydrate	Sensory acceptance study	Low acceptance associated with taste and aroma	Need to improve pediatric formulations and make phosphoric acid more palatable
Craig's restorative dental materials	Sakaguchi & Powers, 2012	Compilation of the properties and use of restorative dental materials	Technical book	Provides complete technical foundations on restorative materials	Fundamental reference for dental materials, mainly phosphoric acid

Source: prepared by the authors, 2026.

The analysis of the articles selected in Table 2 evidenced a growing concern with the adverse effects of the use of phosphoric acid, especially in pediatric dental patients. Although phosphoric acid at 37% is widely used as a conditioning agent due to its efficacy in creating micro-retentions in dental enamel (Lenzi *et al.*, 2016), its use in children requires caution. The studies indicate that, in addition to causing sensations of burning or discomfort in the oral cavity, the product has an intensely acidic taste, which compromises acceptance by the pediatric patient (Parihar; Pilania, 2012). Such a factor can generate resistance to treatment, hinder cooperation during procedures and, in some cases, result in reflexes such as nausea or refusal to continue care (Peumans *et al.*, 2015).

In addition, the reviewed literature highlights that repeated exposure to phosphoric acid can potentially affect adjacent soft tissues, especially when there is no adequate isolation of the application area (Lenzi *et al.*, 2016). Although the material continues to be a standard choice in adhesive restorative protocols, there is a growing interest in less aggressive

alternatives, such as conditioners with the addition of flavourings or agents with a less acidic pH (Cardoso *et al.*, 2021). The critical analysis of recent scientific production reinforces the need for innovation in the formulation of phosphoric acid to improve the clinical experience and comfort of pediatric patients.

4 FINAL CONSIDERATIONS

Dental treatment in children requires not only technical attention, but also sensitivity regarding the particularities of the child population. Phosphoric acid, widely used as a conditioning agent, fulfils a fundamental role in restorative procedures; however, its markedly unpleasant taste can generate discomfort, anxiety and even refusal on the part of the child, interfering with the quality of care and adherence to treatment.

The analysis of the literature revealed a growing number of studies aimed at improving the sensory properties of this product, especially with the addition of flavourings. Other options can be suggested to be experimentally studied with the acid, for example: gums, natural extracts, polymers, nanoparticles, nanocomposites and nanocoatings for preparations that may assist in masking the taste and enhancing the action of phosphoric acid in the dental environment. Although promising, this approach demands complementary investigations that prove the safety, stability and clinical efficacy of these modifications.

Thus, it is concluded that the development of more palatable dental materials represents a significant advance for dentistry, especially pediatric dentistry, with the potential to make care more welcoming and effective, promoting a better experience for the patient and the professional.

REFERENCES

- ALVES, Wellington Pereira. Sinalário em LIBRAS na dentística restauradora para inclusão de surdos na odontologia. 2026. Dissertação (Mestrado Profissional em Propriedade Intelectual e Transferência de Tecnologia para Inovação – PROFNIT) – Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, Campina Grande, 2026. Disponível em: <https://repositorio.ifpb.edu.br>. Acesso em: 28 maio 2026.
- CARDOSO, M. V. *et al.* Efeitos sensoriais de agentes condicionadores modificados com flavorizantes em odontopediatria. *Jornal Brasileiro de Odontologia Infantil*, v. 9, n. 1, p. 34-41, 2021. Disponível em: <https://lume.ufrgs.br/handle/10183/81891>. Acesso em: 5 abr. 2025.
- GONÇALVES, Ana Paula Rodrigues *et al.* Modificação e avaliação de gel de ácido fosfórico 35% com agente aromatizante. *Journal of Oral Investigations*, v. 8, n. 2, p. 49-58, 2019. Disponível em: https://www.researchgate.net/publication/334435014_Modificacao_e_avaliacao_de_gel_de_acido_fosforico_35_com_agente_aromatizante. Acesso em: 29 mar. 2025.

- LENZI, T. L.; GIMENEZ, T.; TEDESCO, T. K.; MENDES, F. M.; ROCHA, R. de O.; RAGGIO, D. P. Adhesive systems for restoring primary teeth: a systematic review and meta-analysis of in vitro studies. *International Journal of Paediatric Dentistry*, v. 26, n. 5, p. 364-375, 2016. Disponível em: <https://doi.org/10.1111/ipd.12210>. Acesso em: 5 abr. 2025.
- MEDEIROS, M. S. G.; GARRUTI, D. S. Estudos de palatabilidade de medicamentos: análise sensorial e aceitabilidade de formulações pediátricas. *Vigilância Sanitária em Debate*, v. 6, p. 44-53, 2018. Disponível em: https://www.researchgate.net/publication/325585648_Estudos_de_palatabilidade_de_medicamentos_analise_sensorial_e aceitabilidade_de_formulacoes_pediatricas. Acesso em: 5 abr. 2025.
- OLIVEIRA, Ana Luiza Koch *et al.* Influência da utilização de ácido glicólico e adesivos universais na qualidade da camada híbrida em restaurações adesivas: revisão de literatura. *Revista Fluminense de Odontologia*, v. 2, n. 64, p. 45-59, 2024. Disponível em: <https://periodicos.uff.br/ijosd/article/view/57840>. Acesso em: 29 mar. 2025.
- PARIHAR, N.; PILANIA, M. SEM evaluation of effect of 37% phosphoric acid gel, 24% EDTA gel and 10% maleic acid gel on the enamel and dentin for 15 and 60 seconds: an in-vitro study. *International Dental Journal of Student's Research*, v. 1, p. 1-13, 2012. Disponível em: <https://www.idjsronline.com/volume/58/issue/89#>. Acesso em: 5 abr. 2025.
- PEUMANS, M.; DE MUNCK, J.; VAN LANDUYT, K.; VAN MEERBEEK, B. Thirteen-year randomized controlled clinical trial of a two-step self-etch adhesive in noncarious cervical lesions. *Dental Materials*, v. 31, p. 308-314, 2015. Disponível em: <https://www.sciencedirect.com/science/article/pii/S0109564115000196>. Acesso em: 5 abr. 2025.
- PLÁ, Ana Laura De Oliveira *et al.* Avaliação de gel ácido fosfórico com agente aromatizante. In: CONGRESSO DE INICIAÇÃO CIENTÍFICA, 25., 2016, Pelotas. Anais [...]. Pelotas: UFPEL, 2016. p. 4463-4467. Disponível em: http://cti.ufpel.edu.br/siepe/arquivos/2016/CS_04463.pdf. Acesso em: 5 abr. 2025.
- REINOL, F. C. Palatabilidade de formulações farmacêuticas pediátricas a base de hidrato de cloral. 2014. Monografia (Curso de Tecnologias Industriais Farmacêuticas). Disponível em: <https://arca7.fiocruz.br/bitstreams/a1ad4e3bc31e-42b8-b844-87439e29912f/download>. Acesso em: 5 abr. 2025.
- SAKAGUCHI, R. L.; POWERS, J. M. *Craig's restorative dental materials*. Philadelphia, PA: Elsevier/Mosby, p. 161-198, 2012. Disponível em: <https://evolve.elsevier.com/cs/product/9780323082747?role=student>. Acesso em: 5 abr. 2025.

REALIZAÇÃO:



ACESSE NOSSO CATÁLOGO!



WWW.SEVENPUBLI.COM

CONECTANDO O **PESQUISADOR** E A **CIÊNCIA** EM UM SÓ CLIQUE.