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SUMMARY

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ORIGINAL ARTICLE

EVALUATION OF THE ORAL HEALTH OF CHILDREN AND ADOLESCENTS WITH LEUKEMIA TREATED AT HEMORIO

AVALIAÇÃO DA SAÚDE BUCAL DE CRIANÇAS E ADOLESCENTES COM LEUCEMIA ATENDIDAS NO HEMORIO

Elanne Cristina Garcia Da Costa Félix[1], Cíntia Tereza Lima Ferraro[2], Raquel Dos Santos Pinheiro[2,3]

ABSTRACT

This study aimed to evaluate the oral health of child and adolescent participants diagnosed with leukemia, assisted by dentistry. The research was configured as cross-sectional, descriptive and observational. All children and adolescents enrolled in the hematological reference center, aged 3 to 18 years, diagnosed with leukemia, treated by the institution, between June 2022 and January 2023 were included. Sociodemographic, medical, dental and laboratory data were collected; followed by a clinical dental evaluation and photographic recording. To assess the prevalence of caries, the index of decayed, missing, filled teeth per tooth and the index of decayed primary teeth, indicated for extraction and filling, were used. The evaluation of oral manifestations was carried out according to the World Health Organization protocol. The research included 25 participants, 14 male and 11 female and the average age was 10.12 years (SD = 4.8). Acute lymphoblastic leukemia was the most prevalent (80%). Regarding the caries index, the majority of participants had zero (60%) and oral side effects were diagnosed in 60% of them, the most frequent being: change in taste (24%), mucositis (16%) and xerostomia (12%). Participants also had a high incidence of oral manifestations, unsatisfactory oral hygiene, but a low rate of caries. Furthermore, it is important for dental surgeons to know the oral manifestations most commonly found in children with leukemia, the need for quality oral hygiene, as well as the oral health condition as a whole, seeking to ensure that the mouth is not a source of infection, which harms the general health condition and cancer treatment.

Keywords: Leukemia, Leukemia Lymphoid, Medical Oncology, Oral Manifestations, Dental Caries, Pediatric Dentistry.

RESUMO

Esta pesquisa transversal, descritiva e observacional objetivou avaliar a saúde bucal dos participantes infantojuvenis diagnosticados com leucemia, assistidos pela odontologia. Foram incluídas todas as crianças e adolescentes de 3 a 18 anos matriculadas no centro de referência hematológico e diagnosticados com leucemia, atendidos pela instituição, entre junho/2022 e janeiro/2023. Foram coletados os dados sociodemográficos, médicos, odontológicos e laboratoriais, seguidos de uma avaliação clínica odontológica e registro fotográfico. Para avaliação da prevalência de cárie utilizou-se o índice de dentes cariados, perdidos, obturados, por dente e o índice de dentes decíduos cariados, indicado a extração e obturado. A avaliação das manifestações orais foi realizada conforme protocolo da Organização Mundial de Saúde. Compuseram a pesquisa 25 participantes, 14 masculinos e 11 femininos, a média de idade foi de 10,12 anos (d.p. = 4,8). A leucemia linfoide aguda foi a mais prevalente (80%), a maioria dos participantes apresentou índice de cárie zero (60%), as manifestações orais foram diagnosticadas em 60% deles, sendo as mais frequentes: alteração de paladar (24%), mucosite (16%) e xerostomia (12%). Os participantes também apresentaram alta incidência de manifestações orais, condição de higiene bucal insatisfatória, porém baixo índice de cárie. Outrossim, observa-se a importância de os cirurgiões dentistas conhecerem as manifestações orais mais encontradas em crianças com leucemia, a necessidade da higiene bucal de qualidade, bem como a condição de saúde bucal total, buscando garantir que a boca não seja uma fonte de infecção que prejudique a condição de saúde geral e o tratamento oncológico.

Palavras-chave: Leucemia, Leucemia linfoide, Oncologia, Manifestações bucais, Cárie dentária, Odontopediatria.

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INTRODUCTION

Blood cells originate in the bone marrow, produced by hematopoietic stem cells, and the condition of leukemia is determined when these immature cells undergo disordered proliferation. According to the National Cancer Institute of Brazil (INCA), leukemia is a malignant disease of generally unknown origin and one of the main diseases affecting hematological patients. According to the institute, more than 11,000 cases will be diagnosed in Brazil between 2023 and 2025, with the most frequent tumors being in children and adolescents, affecting the central nervous system and lymph nodes (1,2,3,4,5).

Leukemias can be classified into 12 types, combining several classifications, such as based on speed (acute and chronic); based on the precursor cells affected (lymphoid or myeloid); those affecting lymphoid cells (lymphoid, lymphocytic or lymphoblastic); and those affecting myeloid cells (myeloid or myeloblastic). The four most common types of leukemia are chronic lymphoid leukemia (CLL), chronic myeloid leukemia (CML), acute lymphoid leukemia (ALL) and acute myeloid leukemia (AML), with ALL being the most common category in children under 15 years old, while CLL and AML have a higher incidence in older people (3).

Treatment depends on the type of leukemia, with the aim of destroying the leukemia cells to ensure the functioning of the bone marrow and re-establish the production of normal cells. Possible treatments include chemotherapy, bone marrow transplantation, target therapy, immunotherapy and the use of monoclonal antibodies, while the local treatments of surgery and radiotherapy are used infrequently (3).

The appearance of oral manifestations can occur in the initial phase of leukemia due to immunosuppression, or because of treatment, since the dose and type of medication influence the worsening and intensity of these manifestations (6). Specifically, the oral manifestations linked directly to the disease that most affect children with leukemia are a depapillated and ulcerated tongue, mucosal pallor, gingival hypertrophy, and gingival bleeding; while those resulting from treatment include dental caries, mucositis, xerostomia, and ulcerations, in addition to opportunistic infections such as candidiasis and herpes (7).

As the oral health can interfere with systemic health condition, especially in immunocompromised patients undergoing chemotherapy treatment, this study proposed to evaluate the oral health of pediatric and adolescent patients diagnosed with leukemia who receive dental care at a hematology referral center in Rio de Janeiro.

METHODOLOY

This cross-sectional, descriptive, and observational study included all children and adolescents enrolled at the State Institute of Hematology “ARTHUR DE SIQUEIRA CAVALCANTI” (HEMORIO, Rio de Janeiro, Brazil), aged between 3 and 18 years, with a diagnosis of leukemia, either hospitalized or in outpatient care. Participants who had outdated institutional registration data due to communication impediments were excluded, as were participants diagnosed with leukemia who had some kind of disturbance of consciousness, dementia, delirium, psychosis, mental disorder or mental illness. The study took place from June 2022 to January 2023, in the dental outpatient clinic of the reference center for hematological treatment and in the pediatric hospital and was approved by the Ethics and Research Committee of the reference center for hematological treatment, by the number 5825156 of 2022.

The participants’ sociodemographic data and medical history, such as definitive diagnosis of leukemia (ALL, CLL, AML, CML), treatment phase (induction, consolidation and maintenance), use of medication and laboratory tests (last blood count collected closest to the time of the clinical dental evaluation) were obtained from the electronic system of the reference center for hematological treatment and from the participant’s medical records, and the anamnesis was taken with the caregiver and the participant. A clinical dental assessment was then carried out, followed by a photographic record. The clinical examination was carried out by a single dentist specializing in pediatric dentistry, after being calibrated by an experienced specialist. To check intra-examiner calibration, a second clinical examination was carried out on 10% of the sample after 2 weeks, with a kappa coefficient of 0.93. It was carried out under a natural light source, using a mirror, gauze and personal protective equipment (PPE). Alterations to the labial commissures, nose, cheek and chin were assessed, as well as alterations to the lymph nodes in the extraoral region. During the intraoral examination, the dental elements, tongue, floor of the mouth, gums, jugal mucosa, hard and soft palates, tonsils and mucous membranes were assessed (8).

To assess the prevalence of caries, the decayed, missing and filled teeth per tooth (DMFT) index and the decayed primary teeth, indicated for extraction and filling index (dmft) were used . The DMFT index measures the mean index of decayed, missing, and filled permanent teeth, as indicated in Table 1, while the dmft index is the dental index for counting the quantity of deciduous elements with indication for extraction, decayed, and filled (9,10,11).

TABLE 1: DMFT INDEX

Average DMFT value	Caries prevalence in the population
0 to 1.1	Very low
1.2 to 2.6	Low
2.7 to 4.4	Moderate
4.5 to 6.5	High
6.6 or higher	Very high

Source: World Health Organization – WHO (9)

Oral manifestations were assessed according to the World Health Organization (WHO) protocol (8).The hematological data classifications of thrombocytopenia and neutropenia were considered by the absolute neutrophil count (ANC), which measures the number of neutrophil granulocytes present in the blood, and thrombocytopenia was defined by the platelet count (12).

TABLE 2: CLASSIFICATION OF NEUTROPENIA AND THROMBOCYTOPENIA

Neutropenia (cells/mm^3)
Normal (highest 1500)
Mild (1000 to 1500) - minimal risk of infection
Moderate (500 to 1000) - moderate risk of infection
Severe (under 500) - serious risk of infection
Thrombocytopenia (thousand fragments/mm^3)
Normal (greater 150 to 450)
Light (100 to 150)
Moderate (50 to 99)
Severe (under 50)

Source: Hemograma: manual de interpretação, 2003 (12)

As a data collection tool, we used forms produced by the researcher, comprising: two record forms (examiner's form and anamnesis), a clinical assessment form (examiner's form) and three record form templates, according to the stage of dentition (deciduous, mixed, and permanent dentition). Statistical analyses were carried out using the PlanMaker for Windows 11 program. Frequency distribution was assessed using absolute (n) and relative (%) data.

RESULTS

Twenty-five participants took part in the survey, 14 of whom were male (56%) and 11 female (44%). The average age was 10.12 years (Standard Deviation - SD = 4.8), with a minimum age of 4 and a maximum age of 17. Of the total number of participants, 12 were hospitalized, while 13 had an outpatient approach. In terms of sociodemographic characterization, 15 were residents of the state of Rio de Janeiro, while 10 lived in the capital city. As for the participants' level of education, 16 were studying and the highest level of education attained was incomplete primary education. As for the caregivers, 39% had completed high school. In terms of employment, 67% of the caregivers were employed.

Regarding the oncological and laboratory aspects: of the 25 participants, 16 (64%) were recently diagnosed (between 2021 and 2022), while the others have been dealing with the disease for a longer period (from 2010 to 2020). There were 20 cases of ALL (80%), 3 of AML (12%) and 2 of CML (8%). As for chemotherapy treatment, the AIEOP/BFM 2009 protocol, version 2013, was the most commonly used treatment method. As informed by the blood center's hematologists, this protocol uses the stratification of patients according to risk groups for recurrence. With regard to the treatment phase, 12 participants were in the induction phase, three in the consolidation phase, three in the maintenance phase, six in control and one in post-hematopoietic stem cell transplant (HSCT) follow-up. The clinical data found is shown in Table 3.

TABLE 3: CLINICAL AND LABORATORY DATA

Clinical Data	
Diagnosis	
Type	% (n)
ALL	80 (20)
AML	12 (3)
CML	8 (2)
Treatment	
Phase	% (n)
Induction	48 (12)
Consolidation	12 (3)
Maintenance	12 (3)
Control	24 (6)
Post-HSCT follow-up	4 (1)
Chemotherapy use % (n)	
Yes	68 (17)
No	32 (8)
Neutrophill count % (n)	
Normal	60 (15)
Mild Neutropenia	0 (0)
Moderate Neutropenia	4 (1)
Severe Neutropenia	36 (9)
Platelet count % (n)	
Normal	56 (14)
Mild thrombocytopenia	12 (3)
Moderate thrombocytopenia	4 (1)
Severe thrombocytopenia	28 (7)

Source: Hemograma: manual de interpretação, 2003 (12)

In the clinical evaluation, the presence of biofilm was observed in the majority of participants (84%); tongue coating was observed in almost half (44%); and calculus, gingival bleeding and gingivitis in smaller proportions (20%, 8% and 4%, respectively). As for the DMFT/dmft index, 60% of the participants had an index equal to 0, with a mean of 1.92 and a standard deviation of 3.82. According to the WHO DMFT index, this group of participants has a low DMFT prevalence.

Considering the clinical analysis and the DMFT/dmft value, it was observed that 84% (n=21) of the participants had biofilm and needed dental follow-up. When considering participants with a DMFT/ dmft greater than 0, bleeding, gingivitis and/or calculus, 52% (n=13) required dental intervention. As a result, 92% (n=23) of the participants needed dental follow-up or intervention (among the necessary interventions, oral hygiene guidance and periodontal care stand out).

Oral manifestations were found in 60% (n=15) of the total sample studied, including dry lips, altered taste, xerostomia, mucositis, gingival hypertrophy, primary herpetic gingivostomatitis and angular cheilitis, the incidences of which are shown in Table 4. Nausea was also observed in 44% (n=11) of the participants.

TABLE 4: PREVALENCE OF ORAL MANIFESTATIONS

Oral manifestations % (n)	
Dry lips	28 (7)
Change in taste	24 (6)
Mucositis	16 (4)
Xerostomia	12 (3)
Gingival hypertrophy	4 (1)
Primary herpetic gingivostomatitis	4 (1)
Angular cheilitis	4 (1)

With regard to oral manifestations in the last 30 days, the data collected from the medical records revealed mucositis (16%), primary herpetic gingivostomatitis (8%), pericoronaritis (4%) and angular cheilitis (4%). Dental anomalies were found in 24% (n=6) of the participants. The anomalies observed included dental crowding (16.7%), prolonged retention (16.7%), late eruption (16.7%) and gyroversion (8.3%). Dental anomalies included hypodontia 16.7% (n=2), microdontia 16.7% (n=2), and twinning/fusion 8.3% (n=1). Low-power laser photobiomodulation therapy was performed in 44% (n=11) of the patients and the indications for this type of treatment are listed in Table 5.

TABLE 5: INDICATIONS FOR PHOTOBIOMODULAR THERAPY

Indication	% (n)
Prophylactic protocol	45.4 (5)
Mucositis	36.4 (4)
Angular cheilitis	9.1 (1)
Herpes	9.1 (1)

DISCUSSION

The participants in the study had unsatisfactory oral hygiene, as seen in the presence of biofilm in 84% of the sample. This condition tends to make them more susceptible to colonization by multidrug-resistant microorganisms, due to their immunocompromise (14). In this study, immunosuppression was observed in 40% of the participants (represented by the neutrophil count), thus showing susceptibility to colonization by microorganisms in the group of participants studied. In this context, preventive treatment and educational work should be reinforced, avoiding infections that could increase hospitalization time and costs, as well as interrupting treatment (15).

The results of the DMFT/dmft indices showed that 40% of the participants had caries disease. In 2020, Afshar *et al*. evaluated 50 children with ALL and observed a mean DMFT of 4.01 (SD = 3.60) 16. In 2019, De Oliveira *et al*., in a study of 61 children and adolescents with malignant neoplasms, observed a mean dmft and DMFT of 2.8 (±3.3) and 1.7 (±1.5) (17). These data corroborate the research findings, with a mean DMFT = 1.92 (SD = 3.82) in all the individuals surveyed and a mean DMFT = 1.85 (SD = 4.20) in the participants with ALL.

It was found that 92% of the child and adolescent cancer patients treated at the reference center for hematological treatment needed dental follow-up or intervention, in addition to the presence of caries, bleeding, gingivitis, calculus and biofilm. The regularity and form of brushing, when not performed correctly, can increase caries rates, and this unsatisfactory oral condition tends to accentuate the development of infections during the myelosuppression process (18). Odontogenic infections can be the source of systemic infections during periods of myelosuppression, as well as causing secondary infections related to central venous access, and it is important to eliminate them or minimize their risks (19,21).

Chemotherapy is a widely used antineoplastic treatment and it is important to understand the protocols used in the treatment of leukemia due to the possible side effects of these drugs. This form of treatment can be administered alone or in combination with other medications. Administration takes place at regular intervals which vary according

to the protocol used (20). The most commonly used protocol among the participants surveyed was the BFM (Berlin-Frankfurt-Munich) protocol, which uses reinduction therapy during the consolidation phase, reusing the same medications administered during the induction phase (22).

The drugs used in chemotherapy are divided into groups of alkylating agents, antitumor antibiotics, mitotic inhibitors, antimetabolites, corticosteroids (prednisone, prednisolone, dexamethasone) and asparaginase, among others. These medications can cause side effects such as nausea and vomiting (20). These effects were reported by 44% of patients, who may have their oral hygiene affected by avoiding brushing or mouthwash.

Leukemia is characterized by a high incidence of oral complications at the time of diagnosis and during treatment. On some occasions, patients with leukemia may come to dental care before the medical diagnosis, for routine care or for some oral manifestation of leukemia, such as gingival hyperplasia and gingivitis (7,23). A detailed anamnesis combined with laboratory tests can highlight to the dentist the possibility of blood dyscrasia, requiring attention for a differential diagnosis and referral of the patient to a hematologist.

Oral manifestations can be divided into three groups based on the causative agent. Primary lesions are induced by the infiltration of malignant cells into oral structures: gingival infiltration and infiltration into bony oral structures. Secondary lesions result from the myeloid nature of the disease and this group includes signs and symptoms as anemia, increased bleeding tendency and increased susceptibility to infections. On the other hand, tertiary complications are usually due to the complex interaction of the therapy itself, its side effects or a systemic condition resulting from the therapy. Such lesions and complications include ulcerations, mucositis, altered taste, candidiasis, gingival bleeding, xerostomia, dysphasia, opportunistic infections and trismus (24).

Chemotherapy acts on cells with a high rate of renewal, such as the cells of the oral mucosa, generating alterations in the integrity of these cells, causing changes in the oral microbiota, salivary flow and biochemistry and epithelial maintenance (7,20). Some chemotherapy drugs such as cytarabine, mitoxantrone and methotrexate are used in pediatric oncology and are closely related to the onset of mucositis (20).

All the participants were undergoing chemotherapy (68%) or post-chemotherapy (32%). Thus, the primary oral/dental manifestations (primary lesions) were not identified, because there were no participants before cancer treatment. Among the secondary oral manifestations, gingival bleeding was observed in 8% of the participants, herpetic gingivostomatitis in 4% and angular cheilitis in 4%. Lopes apud Caldas *et al*., in 2021, found a percentage of 25% of gingival bleeding in the sample of a study involving 24 children aged between 6 and 12 with an oncological diagnosis, 50% of whom had leukemia. Although the sample size of Lopes and the present study was similar, there was a significant difference in these findings, probably because they assessed other types of cancer (21).

In a 2018 study of 71 children and adolescents with ALL, Pinto *et al*. found that 4.9% had gingival bleeding, 3.3% had herpetic gingivostomatitis and 1.6% had angular cheilitis. Apart from the result of herpetic gingivostomatitis, which is similar to the result of the present study, the other values are divergent and this may be related to the difference in sample size in the two studies, the difference in protocols used or the quality of the oral health and/or clinical condition of those interviewed (25).

As for tertiary manifestations, xerostomia was found in 12% and mucositis in 16% of the sample. Pias *et al*. (2020), after evaluating 162 medical records of children with leukemia, found an incidence of 6.17% of xerostomia. This difference may be associated with the difference in sample size, for having covered other types of hematological cancers, or for different chemotherapy treatment protocols (26).

Regarding mucositis, Lopes apud Caldas *et al*., in 2021, found that in a total of 24 children, 62.5% had mucositis (21). Pinto *et al*. in 2018 detected the oral alteration of mucositis in 72.1% of 71 children and adolescents (24), while Lima *et al*. in 2022, when studying 117 children undergoing antineoplastic therapy, observed the appearance of mucositis in 66.7% of the participants surveyed (27). The differences in the authors' percentages in relation to this study may be due to the difference in sample size, the difference in treatment protocol or the fact that most of the patients at the reference center for hematological treatment were undergoing prophylactic photobiomodular treatment.

Altered taste is one of the side effects of chemotherapy, due to changes in the salivary glands, and can be mild or more complex, involving all four types of taste (28). Fernandes and Spinelli, in 2020, carried out a cross-sectional study with 17 family members of children undergoing cancer treatment (57.9% referring to children undergoing cancer treatment for leukemia) and found 63.2% reported changes in taste (29). In the present study, a lower percentage (24%) of patients declared alterations in taste.

One adolescent had microdontia, prolonged retention and delayed eruption. As well as receiving chemotherapy as an anti-neoplastic treatment, he

underwent radiotherapy at the age of three years-old. The treatment data was obtained by interviewing the caregiver, without access to the records of the drugs used and the dosage of radiotherapy applied at the time. The literature shows that chemotherapy drugs, and especially radiotherapy drugs in the head and neck region, can interfere with odontogenesis and can result in dental alterations such as agenesis and hypodontia when applied before the morphodifferentiation phase of the ameloblasts. If it occurs later in tooth development, microdontia, hypoplasia and root malformation are expected side effects. In addition, alkylating agents such as cyclophosphamide can cause tooth agenesis and microdontia, while vincristine and doxorubicin can affect the development of odontogenic tissues (20,30).

The participants in the study are being treated for an acute life-threatening illness. The discovery of cancer also alters the routine of their families, who begin to experience suffering plus worries and demands (31). Treatment should be carried out by a multi-professional team, starting with qualified and empathetic listening, with the aim of prevention and health promotion. The dental surgeon on this team should raise awareness among caregivers and children about the importance of oral health, encourage greater adherence to treatment, promote the adaptation of the oral environment and reduce the likelihood of invasive treatments, as infectious foci are a severe threat to the health of immunosuppressed patients. Dental care for this group of participants should be carried out before, during and after cancer treatment (13,32).

In addition, the main limitations to conducting this research were the number of participants seen during the period, their attendance at appointments and the difficulty in communicating with the participants and their guardians. Further studies on this subject are suggested in order to reach a larger number of participants.

Despite the limitations presented, this study is of great scientific relevance, as it demonstrates that the dental surgeon can be the first to observe a clinical manifestation of leukemia. In addition, in the stages of treatment with significant immunosuppression, this professional acts in the prevention and treatment of oral manifestations, providing an ideal hygiene condition to avoid complications arising from a poor oral condition.

CONCLUSION

Children and adolescents with leukemia who receive dental care at a reference center for hematological treatment have a high percentage of oral manifestations and unsatisfactory oral hygiene, making them more susceptible to infections. This reinforces the need for the dental surgeon to continuously monitor patients during all phases of antineoplastic treatment, reinforcing their importance in the multidisciplinary team that treats this group of patients.

The authors declare that there is no conflict of interest and that they have no economic or other interests that could cause embarrassment if known after the article has been published.

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REFERENCES

1. CANCER.ORG. What Is Acute Myeloid Leukemia (AML)?. [S. l.], 21 ago 2018 (Accessed on Mar 13rd, 2022). Available at: https://www.cancer.org/cancer/acute-myeloid-leukemia/about/what-is-aml.html.
2. Peixoto LSB, Gomes JO. Atuação do cirurgião dentista no tratamento de pacientes com câncer no Brasil de 2013 à 2023. REASE. 2023;9(10):1686-701.
3. Instituto Nacional de Câncer. TIPOS de câncer: Leucemia. [S. l.], 20 ago 2021 (Accessed on Mar 20th, 2022). Available at: https://www.inca.gov.br/tipos-de-cancer/leucemia#:~:text=A%20leucemia%20%C3%A9%20uma%20doen%C3%A7a,substituem%20as%20c%C3%A9lulas%20sangu%C3%ADneas%20normais.
4. Hemorio. Manuais. In: Manuais. [S. l.], 2014 (Accessed on Mar 20th, 2022). Available at: http://www.hemorio.rj.gov.br/.
5. Instituto Nacional de Câncer. Estimativa 2023: incidência de câncer no Brasil. Rio de Janeiro: INCA; 2022 (Accessed on Jan, 31st, 2023). Available at: https://www.inca.gov.br/sites/ufu.sti.inca.local/files//media/document//estimativa-2023.pdf.
6. Teixeira AM, Perez JMP, Pereira VAS. Manifestações orais em pacientes submetidos a quimioterapia e radioterapia. Diálogos em Saúde. 2022;4(2):72-83.
7. Pereira EML, Gomes IA, de Sousa ACC, Ferreira GLC. Pacientes oncológicos pediátricos: Manifestações orais decorrentes da terapia antineoplásica. Revista de Estudos Multidisciplinares UNDB. 2023;3(1).
8. World Health Organization. Oral health surveys: basic methods - 5th edition. World Health Organization; 2013. ISBN 978-92-4-154864-9.
9. World Health Organization. International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY. World Health Organization; 2007.

10. Agnelli PB. Variação do índice CPOD do Brasil no período de 1980 a 2010. Rev Bras Odontol. 2016;72(1/2):10-5.
11. Han L, Wang Qi. Associations of brominated flame retardants exposure with chronic obstructive pulmonary disease: A US population-based cross-sectional analysis. Front Public Health. 2023;11:1138811.
12. Lupp JS, Silva LAA. The importance of interpreting complementary laboratory tests in routine dentistry: A brief review. Int J Health Res. 2023;2(6):1533-45.
13. de Andrade LC, Gomes SL, Santos TB. Papel do Cirurgião Dentista nos cuidados paliativos multidisciplinares com pacientes oncopediatricos: revisão integrativa. Res Soc Dev. 2022;11(6):e27911629189.
14. Tejo NP, Andrade KS, Ferreira AFM. Condição oral de pacientes imunocomprometidos internados em Unidade de Terapia Intensiva. Arch Health Invest. 2021;10(4):674-9.
15. Farias GLC, Sousa HMM, Pereira LS, de Carvalho ALA, de Melo Júnior WA. Laserterapia e Ações Educativas Transdisciplinares na Oncologia Pediátrica. Caderno Impacto em Extensão. 2023;3(1):1-4.
16. AFSHAR MK, Farahmandinia Z, Parizi MT, Parivar F. Oral Health Status of South-Eastern Iranian Children with Acute Lymphoblastic Leukemia. JJ Evol Med Dent Sci. 2020;9(2):86-91.
17. Ponte YO, Ximenes RDA, Vasconcelos AA, Girão DC. Saúde bucal em crianças com câncer: conhecimentos e práticas dos cuidadores. Revista da Faculdade de Odontologia-UPF. 2019;24(2):183-91.
18. Rosso MLP, Neves MD. de Araújo PF, Ceretta LB, Simões PW, Sônego FGF, *et al*. Análise da condição bucal de pacientes pediátricos e adolescentes portadores de neoplasias na instituição Casa Guido na Cidade de Criciúma (SC). Revista de Odontologia da Universidade Cidade de São Paulo. 2015;27(3):210-9.
19. Buzetto JC, Brito RCM, Imparato JCP. Há um protocolo odontológico para prevenção e tratamento de doenças bucais em crianças submetidas ao tratamento oncológico? Revisão integrativa. Res Soc Dev. 2023;12(2):e15512240100.
20. de Souza JLR, de Araújo ACS, do Nascimento FSL. O Papel do Farmacêutico na Adesão De Pacientes em Uso de Antineoplásicos Orais. Revista Eletrônica da Estácio Recife. 2019;5(2):1-12.
21. Caldas LHTA, Ricarte RG, Souza e Souza SR, Néri JSV, Dantas JBL. Alterações orais da quimioterapia em pacientes infantojuvenis com leucemia linfoide aguda: uma revisão de literatura. Revista Brasileira de Saúde Funcional. 2021;9(2):133-50.
22. Tessmann L, Medeiros-Souza P, Códoba JCM, Tavares NUL, Abílio VM. Matos DO, *et al*. Partição de Comprimidos Antineoplásicos Utilizados no Tratamento de Leucemias Agudas em Crianças e Adolescentes. Revista Brasileira de Cancerologia. 2020;66(2):e-01764.
23. Araújo NS, Cezário LRA, Gois CMB, Araújo AB, de Araújo DVA, de Alburquerque SAV, *et al*. Condições bucais e o impacto na qualidade de vida de crianças e adolescentes em tratamento antineoplásico. Braz J Develop. 2023;9(2):7014-31.
24. Silveira ACAS, Coutinho LN, Correa GTB. Manifestações orais em pacientes pediátricos com Leucemia Linfoide Aguda. Res Soc Dev. 2022;11(7):e27711730119.
25. Pinto ETF, Queiroz SIML, Gonçalves P, Gurgel BCV. Avaliação retrospectiva das alterações orais em crianças com leucemia linfoblástica aguda. Revista Portuguesa de Estomatologia, Medicina Dentaria e Cirurgia Maxilofacial. 2018;59(1):30-5.
26. Pias MCM, Neto GOP, Ferreira CMB, Libório-Kimura TN. Manifestações bucais da leucemia linfoblástica: estudo clínico em centro de referência hematológico no Amazonas. Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial. 2020;61(3):128-34.
27. de Lima AKMMN, Paulo AC, Duarte DA. Qualidade de Vida e Saúde Bucal em Crianças Submetidas à Terapia Antineoplásica. RBC. 2022;68(2):e-202164.
28. Hernandes CO, de Carvalho MM, Simonato LE. Manifestações bucais em pacientes com leucemia Oral manifestation in patients with leukemia. Braz J Dev. 2021;7(12):110930-43.
29. Fernandes RCS, Spinelli MGN. Percepção de pais e responsáveis por crianças diagnosticadas com câncer: a gastronomia hospitalar em foco. Nutr Clín Diet Hosp. 2020;40(1):20-4.
30. Bendoraitiene EA, Andruskeviciene V, Kscenaviciute G, Srebaliene E, Maciulaityte I. Peculiarities of dental treatment among paediatric oncological patients: A case report. J Oral Maxillofac Res. 2020;11(3):e5.
31. dos Santos PA, Serralta FB. Narrativas sobre o câncer: um estudo clínico-qualitativo em cuidados paliativos. Revista da Sociedade Brasileira de Psicologia Hospitalar. 2019;22(2):301-24.
32. da Silva MVI, de Lima RO, Monteiro VMC, dos Santos SEN, Gaines APL, Rocha LMBM, *et al*. Câncer bucal e o papel do Cirurgião-Dentista no diagnóstico precoce: Revisão integrativa. Res Soc Develop. 2023;12(13):e75121344156.

ORIGINAL ARTICLE

SUN EXPOSURE AND OCCUPATIONAL RISK: RELATIONSHIP AMONG SQUAMOUS CELL CARCINOMA OF THE LIP, ACTINIC CHEILITIS AND ORAL EPITHELIAL DYSPLASIA IN MILITARY AND THEIR RELATIVES

EXPOSIÇÃO SOLAR E RISCO OCUPACIONAL: RELAÇÃO ENTRE CARCINOMA DE CÉLULAS ESCAMOSAS EM LÁBIO, QUEILITE ACTÍNICA E DISPLASIA EPITELIAL ORAL EM MILITARES E DEPENDENTES

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ABSTRACT

Military personnel are considered an occupational risk group for the development of actinic cheilitis (AC) and lip squamous cell carcinoma (LSCC), due to the performance of duties outdoors under constant exposure to ultraviolet (UV) solar rays, which is the main risk factor for these diseases. This study aims to evaluate the relationship between AC and LSCC, associating the presence and degree of severity of oral epithelial dysplasia (OED) with the occupational factor in military personnel and dependents, evaluating the flow of referrals to the Stomatology Clinic of Odontoclínica Central da Marinha (OCM). A retrospective study was carried out on cases of AC or LSCC diagnosed between 2011 and 2023 in the OCM and the variables collected were: sociodemographic, occupational, history of sun exposure, military activity, affected anatomical area, presence and degree of OED, origin of the forwarding. The sample consisted of 89 (91.8%) cases of AC and 8 (8.2%) LSCC. The military personnel represented 83.1% of the AC cases and 75% of LSCC. As for origin, 83.1% of the AC and 62.5% of LSCC came from internal referrals, from the Military Organization itself. OED was present in 72% of the AC, with no statistically significant association between occupational exposure and the presence and severity of OED. Two cases of LSCC had reports of previous AC. This study corroborates data from the literature and demonstrates the importance of military dentists in preventing and treating oral diseases with occupational risk in the Armed Forces.

Keywords: Actinic cheilitis; Lip carcinoma; Oral dysplasia;. Military Personnel;· UV radiation.

RESUMO

Os militares são considerados um grupo de risco ocupacional para o desenvolvimento de queilite actínica (QA) e carcinoma de células escamosas de lábio (CCEL), devido ao desempenho de funções ao ar livre sob constante exposição aos raios solares ultravioleta (UV), sendo este o principal fator de risco destas doenças. Este trabalho tem como objetivo avaliar a relação entre QA e CCEL, associando a presença e o grau de gravidade da displasia epitelial oral (DEO) com o fator ocupacional em militares e dependentes, avaliar o fluxo de encaminhamentos para a Clínica de Estomatologia da Odontoclínica Central da Marinha (OCM). Foi realizado um estudo retrospectivo dos casos de QA ou CCEL diagnosticados no período de 2011 a 2023 na OCM e as variáveis coletadas foram: sociodemográficas, ocupacionais, histórico de exposição solar, atividade militar, área anatômica acometida, presença e grau de DEO. A amostra foi composta por 89 (91,8%) casos de QA e 8 (8,2%) CCEL. Os militares representavam 83,1% dos casos de QA e 75% dos CCEL. Quanto à origem, 83,1% das QA e 62,5% dos CCEL procederam de encaminhamentos internos, da própria Organização Militar (OM). A DEO esteve presente em 72% das QA, não sendo observada associação estatisticamente significativa entre a exposição ocupacional com a presença e gravidade da DEO. Dois casos de CCEL tinham relato de QA prévia. Este estudo corrobora com os dados da literatura e demonstra a importância do Cirurgião-Dentista militar na prevenção e tratamento das doenças orais com risco ocupacional nas Forças Armadas.

Palavras-chave: Queilite; Câncer labial; Displasia epitelial oral; Atividades militares; Radiação solar.

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INTRODUCTION

Oral cancer is a significant public health challenge on a global scale (1–5). In Brazil, according to estimates by the National Cancer Institute, 15,100 new cases of oral cancer are expected a year between 2023 and 2025 (6). Squamous cell carcinoma (SCC) is responsible for approximately 90% of malignant neoplasms of the mouth, with the majority of these cases being preceded by oral potentially malignant disorders (PMD) (6,7).

Particularly, lip cancer represents a significant proportion, comprising around 25 to 30% of oral cancer cases, with 95% of lip cancers being preceded by actinic cheilitis (AC) (6–8).

AC is a PMD of lip vermilion, which mainly affects the lower lip (9–13). Its main risk factor is chronic and progressive exposure to the sun's ultraviolet (UV) rays (10,14,15). Additional factors such as fair skin, advanced age, geographical latitude, male gender, smoking, genetic predisposition, immunosuppression, occupation, and leisure activities with intense sun exposure can also predispose to its development (12,14,16).

Occupational exposure to UV radiation, added to Brazil's geographical latitude, emerges as an important risk factor for developing AC and SCC in the Brazilian population, including the military (4,7,13,16–21). Frequent outdoor activities, such as military activities, physical-military training, standing to attention, boat repairs, and direct exposure to the sun during flight, highlight the military as an occupational risk group, making AC a disease that requires special attention from stomatologists in the Military Forces (17,19,21–23).

The main clinical features of AC include variations in lip color, loss of the boundary between the lip vermilion and the skin, presence of areas of atrophy, crusts, fissures, leukoplakic patches or plaques, erythema and ulcerations on the lip vermilion (7,8,10,24). Histopathologically, it may show stratified squamous epithelium with hyperkeratosis, acanthosis, or atrophy and varying degrees of oral epithelial dysplasia (OED), while the underlying connective tissue usually shows an amorphous basophilic zone called solar elastosis (7,9–11,25,26).

OED can be classified as mild, moderate, or severe, according to the World Health Organization (WHO) criteria. The clinical characteristics and the severity gradation of OED are considered a predictive factor of AC prognosis (27). This study aims to evaluate the relationship between AC and CCEL, associating the presence and degree of severity of OED with the occupational factor in military personnel and dependents of the Navy health system (family members), as well as to map the flow of referrals of these patients to the Stomatology Clinic of the Odontoclínica Central da Marinha (OCM - Navy's Central Dental Clinic), in Rio de Janeiro, Brazil.

MATERIAL AND METHODS

This study was approved by the Research Ethics Committee of the Marcílio Dias Naval Hospital (HNMD) under the number 76263423.8.0000.5256. It is an observational, longitudinal, and retrospective study. The sample was selected by searching the medical records, anatomopathological reports, and photographic records of the OCM Stomatology Clinic for patients with lesions clinically and histopathologically diagnosed as AC or SCC between 2011 and 2023. All cases without a pathological diagnosis were excluded from the final sample.

The following sociodemographic, occupational, and clinical information was collected: sex, age, skin color, rank (officer or enlisted), cadre (navy, marine force, health division, and auxiliary division), outdoor sports practice, affected anatomical area, presence, and degree of OED.

The investigation into the origin of the participants' referrals to the OCM Stomatology Clinic was carried out according to the following criteria: OCM clinics - dentists from other specialties - or external (extra-OCM) - carried out by health professionals (doctors or dentists) from another sector of the Navy Health System (health division of military organizations; Polyclinics or Marcílio Dias Naval Hospital) or from civilian dentists.

Smoking and drinking habits were considered when there was a report of their frequency or eventuality.

Military occupational risk was assessed according to the following functional categorizations: without military occupational risk (relatives of military personnel) (28); or with military occupational risk (active military personnel or veterans).

For the classification of AC, we subdivided the sample into two groups: the first group consisted of reports with a diagnosis of AC without epithelial dysplasia or with mild epithelial dysplasia, and the second group contained reports with a diagnosis of AC with moderate epithelial dysplasia or severe epithelial dysplasia (29).

All the histopathological information obtained was recorded in a Microsoft Office Excel 2010 spreadsheet (Remond, Washington, USA), prepared for this study. A descriptive and inferential analysis was carried out using the statistical program Statistical Package for the Social Sciences (IBM® SPSS Statistics, version 20.0).

The qualitative variables were presented as percentage frequency and absolute frequency [(n)%]. The following test was used to compare the groups

studied Chi-test or Fisher's exact test was used. The significance level established was 5% ($p \leq 0.05$).

RESULTS

From a total of 144 medical records selected, 47 cases of AC diagnosed only clinically were excluded because they did not have a pathological report. As a result, the final sample consisted of 97 cases [89 (91.8%) with a diagnosis of AC and 8 (8.2%) with a diagnosis of SCC].

Evaluation of AC cases

Table 1 describes AC's sociodemographic data. The sample comprised 89 cases, 76 (85.4%) men and 13 (14.6%) women. The age range was 36 to 72, with an average age of 60 (±11.0) years. Most of the individuals were white (n=76/85.4%), drinkers (n=47/52.8%), and non-smokers (n=69/77.5%).

All the patients had AC on the lower lip and only one case was on both lips.

TABLE 1. SOCIODEMOGRAPHIC DATA ON ACTINIC CHEILITIS

ACTINIC CHEILITIS	Total (n=89)	
	n	%
Sex		
Male	76	85.4%
Female	13	14.6%
Age		
<50 years	15	16.9%
≥50 years	74	83.1%
Skin color		
White	76	85.4%
Brown	10	11.2%
Black	2	2.2%
No information	1	1.1%
Smoking		
Yes	2	2.2%
No	69	77.5%
Ex-smoker	18	20.2%
Alcoholic		
Yes	47	52.8%
No	35	39.3%
Former alcoholic	7	7.9%
Smoking + Drinking		
Yes	16	18.0%
No	73	82.0%

OED was present in 64 (72%) lesions, 42 (47.2%) with mild OED, 15 (16.9%) with moderate OED and 7 (7.9%) with severe OED (Table 2).

When analyzing the flow of referrals to the OCM Stomatology Clinic, we observed that most (n=74/83.1%) of patients come from internal referrals from OCM clinics (Table 2).

Military personnel made up the majority of the sample (n=74/83.1%), with 61 (68.5%) veterans and 55 (74.3%) soldiers. The most affected militaries were from Navy personnel, with 47 (63.5%) patients, and from Marine Force, with 22 (29.7%) (Table 2).

When evaluating the occupational exposure factor, it was observed that 65 (73.0%) military patients performed only military occupational activity outdoors, and 9 (10.1%) patients performed both military and civilian work with prolonged sun exposure.

Only 22 (24.7%) patients who did outdoor sports reported leisure activities with sun exposure (Table 2). The occupational exposure variable associated with sports practice was present in only 15 (16.9%) cases.

Regarding the association between the origin of the referral and the degree of OED, we found that among the patients coming from other OCM clinics, most did not have OED or had mild OED (n=21/74; 28.4% and n=38/74; 51.4%, respectively). A statistically significant association was found between the low severity of OED (absence of OED/mild OED) and the OCM sector of origin (Table 2).

In terms of occupational status, the majority of participants had a diagnosis of low severity of OED (no OED/mild OED), with 76.9% (n=10/13) in active service, 73.8% (n=45/61) veterans and 80.0% (n=12/15) dependents. However, no statistically significant association was found between occupational status and the presence and severity of OED (Table 2).

Although military personnel accounted for 86.4% (n=19/22) of those with a diagnosis of greater severity (moderate/severe OED), there was no statistically significant association between occupational exposure and the presence and severity of OED (Table 2).

The majority of participants who did not practice outdoor sports (n=47/62;75.8%) had low severity of OED (no OED/mild OED). However, there was no statistically significant association between practicing outdoor sports and the presence and severity of OED (Table 2), nor was there an association between occupational exposure due to practicing sports and the presence and severity of OED.

The analysis according to the rank showed that the majority of enlisted (n=40/55;72.7%), as well as the majority of officers (n=15/19;78.9%), had a

TABLE 2. DISTRIBUTION OF OCCUPATIONAL DATA BY DIAGNOSIS OF ORAL EPITHELIAL DYSPLASIA

	No OED (n=25/28.0%)		With OED (n=64/72.0%)								
			Mild (n=42/42.2%)		Moderate (n=15/16.9%)		Severe (n=7/7.9%)		Total		p
	n	%	n	%	n	%	n	%	n	%	
Origin											0.038§
OCM	21	23.6%	38	42.7%	11	12.4%	4	4.5%	74	83.1%	
Extra-OCM	3	3.4%	4	4.5%	4	4.5%	3	3.4%	14	15.7%	
No information	1	1.1%	0	0.0%	0	0.0%	0	0.0%	1	1.1%	
Situation											0.872¥
Active	3	3.4%	7	7.9%	3	3.4%	0	0.0%	13	14.6%	
Veteran	18	20.2%	27	30.3%	10	11.2%	6	6.7%	61	68.5%	
Military relative	4	4.5%	8	9.0%	2	2.2%	1	1.1%	15	16.9%	
Occupational exposure											0.754§
Military	21	23.6%	34	38.2%	13	14.6%	6	6.7%	74	83.1%	
Military relative	4	4.5%	8	9.0%	2	2.2%	1	1.1%	15	16.9%	
Outdoor sports/leisure											0.574§
Yes	7	7.9%	8	9.0%	7	7.9%	0	0.0%	22	24.7%	
No	17	19.1%	30	33.7%	8	9.0%	7	7.9%	62	69.7%	
No information	1	1.1%	4	4.5%	0	0.0%	0	0.0%	5	5.6%	
Occupational exposure + Sport											0.204§
Yes	4	4.5%	5	5.6%	6	6.7%	0	0.0%	15	16.9%	
No	20	22.5%	33	37.1%	9	10.1%	7	7.9%	69	77.5%	
No information	1	1.1%	4	4.5%	0	0.0%	0	0.0%	5	5.6%	
Military Rank											0.764§
Enlisted	11	14.9%	29	39.2%	11	14.9%	4	5.4%	55	74.3%	
Officer	10	13.5%	5	6.8%	2	2.7%	2	2.7%	19	25.7%	
Division											0.570¥
Navy	14	18.9%	22	29.7%	8	10.8%	3	4.1%	47	63.5%	
Marine Force	4	5.4%	11	14,9%	5	6.8%	2	2.7%	22	29.7%	
Health division	0	0.0%	1	1.4%	0	0.0%	0	0.0%	1	1.4%	
Auxiliary division	1	1.4%	1	1.4%	1	1.4%	1	1.4%	4	5.4%	

Post/gradation and grade were calculated on the basis of 74 participants. ¥ Chi-square test; §Fisher's exact test.

low severity of OED (no OED/mild OED). However, no statistically significant association was found between officer and enlisted and the presence and severity of OED (Table 2).

Considering the functional category, the Auxiliary division (n=2/4;50.0%) was the group of patients with the highest OED severity rates (moderate OED/severe OED), followed by the Marine Force (n=7/22;31.8%) and the Navy (n=11/47;23.4%). However, there was no statistically significant association between functional status and the presence and severity of OED (Table 2).

Evaluation of lip squamous cell carcinoma cases

Table 3 describes the sociodemographic data of the participants with SCC. The sample consisted of 8 participants, 6 (75.0%) men and 2 (25.0%) women.

The age range was 29 to 78, with an average age of 62.6 (±15.1) years. All the individuals were white (100.0%) and drinkers (100.0%).

The majority had associated smoking habits and present or past alcohol consumption (n=5/8; 62.5%) (Table 3). Regarding origin, 5 (62.5%) came from internal referrals from the OCM.

Two participants had reported previous AC before the diagnosis of SCC. One refused to undergo a diagnostic biopsy and followed up the case, returning after four years with the SCC already developed. The second was followed up for two years, refusing to undergo a diagnostic biopsy and later being diagnosed with SCC (Figure 1:A-D). The other 6 participants had been referred to the Stomatology Clinic with suspicion of SCC and no previous lesions.

Table 4 shows the occupational data of the participants with CCEL. The majority of participants with CCEL came from an internal referral from the OCM (n=5/62.5%), military (n=6/75.0%), veterans (n=5/62.5%), and not practicing outdoor sports (n=5/62.5%). Among the military, most were enlisted (n=4/66.7%), and half were from Navy personnel (n=3/50.0%). However, we found no statistically significant association between occupational data and the diagnosis of SCC.

TABLE 3. SOCIODEMOGRAPHIC DATA ON LIP SQUAMOUS CELL CARCINOMA

ORAL SQUAMOUS CELL CARCINOMA ON THE LIP	Total (n=8)	
	n	%
Sex		
Male	6	75.0%
Female	2	25.0%
Age		
<50 years	1	12.5%
≥50 years	7	87.5%
Skin color		
White	8	100.0%
Brown	0	0.0%
Black	0	0.0%
Smoking		
Yes	3	37.5%
No	3	37.5%
Ex-smoker	2	25.0%
Alcoholic		
Yes	8	100.0%
No	0	0.0%
Former alcoholic	0	0.0%
Smoking + Drinking		
Yes	5	62.5%
No	3	37.5%

Figure 1. Clinical photographs showing the clinical evolution of actinic cheilitis in squamous cell carcinoma of the lip; **A** Initial consultation suggesting a clinical diagnosis of more severe AC; **B** and **C** After two years with suspicion of SCC; **D** Positive toluidine blue test in an area of atrophy, the site of the incisional biopsy.

TABLE 4. SOCIODEMOGRAPHIC DATA ON LIP SQUAMOUS CELL CARCINOMA

ORAL SQUAMOUS CELL CARCINOMA ON THE LIP	Total (n=8)		p
	n	%	
Origin			0.727Φ
OCM	5	62.5%	
Extra-OCM	3	37.5%	
Situation			0.197¥
Active	1	12.5%	
Veteran	5	62.5%	
Relative of military personnel	2	25.0%	
Occupational exposure			0.289Φ
Military	6	75.0%	
Relative of military personnel	2	25.0%	
Outdoor sports/leisure			0.727Φ
Yes	3	37.5%	
No	5	62.5%	
Occupational exposure + Sport			0.070Φ
Yes	1	12.5%	
No	7	87.5%	
Military Rank			0.688Φ
Enlisted	4	66.7%	
Officer	2	33.3%	
Division			0.572¥
Navy	3	50.0%	
Marine Force	1	16.7%	
Health division	1	16.7%	
Auxiliary division	1	16.7%	

¥ Chi-square test; Φ Binomial test

DISCUSSION

This is the first study to evaluate the association between AC and CCEL, analyzing the presence and severity of OED in military personnel and their relatives in the Brazilian Navy, considering sociodemographic and occupational factors. The results indicated that most participants with AC and LSCC are referred to the OCM Stomatology Clinic by other clinics of the various dental specialties of this OM. In addition, the study results showed that, compared with referrals from other sectors of the Brazilian Navy's Health Care System, cases from the OCM had a lower severity of OED. This difference proved to be statistically significant.

These results demonstrate the importance of the Brazilian Navy's Oral Health Program (PSB), published in its manual in 2009 and advocates actions aimed at preventing diseases, promoting health, and raising awareness among users of the Navy's Health System (30). As part of the PSB's preventive measures, the OCM conducts continuous training for health professionals, emphasizing the screening of oral diseases, including identifying AC. With a focus on users of the health system, educational talks on the oral cancer prevention program are given weekly in the OCM's waiting rooms and periodically in operational military organizations, where the importance of early diagnosis of AC and SCC for the military is reported, mainly highlighting preventive measures and the need for early diagnosis. This work focused on prevention through information that may justify the results observed in our study.

In addition, following the guidelines recommended by the PSB for PMD, patients with AC are periodically monitored by the Stomatology Clinic, through a clinical examination carried out by experienced stomatologists, photographic records and the use of the toluidine blue test. Besides, during all the consultations, the professionals reinforce the instructions for prevention and personal care of

AC, emphasizing the importance of using lip balm, wearing a wide-brimmed hat with UV protection, and not exposing yourself to the sun, especially when UV rays are most intense. These practices may have contributed to the low number of cases of AC that progressed to SCC during the 12-year follow-up period covered by this study, but further studies are needed to confirm this data.

According to Medeiros *et al*. (24), malignant transformation of AC into SCC occurs in 10 to 30% of cases, with 95% of SCC preceded by AC. Among our participants, only two were previously diagnosed with AC. Both men, even after being advised of the risk of malignancy of their lesions, chose not to follow up properly, resulting in the malignization of the lesions. The other participants with SCC had already been referred to the Stomatology Clinic with a suspicion of malignancy, which was later confirmed by biopsy.

According to Paulino *et al*. (31), the rate of malignant transformation of AC increases significantly, ranging from 9.6 to 43.2%, when individuals have an occupational function with sun exposure. A study of 212 military veterans of the wars in Afghanistan and Iraq found that 63% of the participants had suffered an acute injury during their mission as a result of sun exposure, and only 23% had been advised of the risk of developing cancer as a result of sun exposure (22). Given the occupational nature of AC in military personnel and the increased risk of developing SCC, our results highlight the crucial role played by the PSB and the Stomatology Clinic in the MB Health System, enabling the prevention, early diagnosis, control and reduction of the rate of malignant transformation of AC.

In a previous study carried out at the OCM Stomatology Clinic, the prevalence of AC was 2.7% of all lesions diagnosed between 2011 and 2014, with military personnel accounting for 79.3% of the 29 cases (18). In a subsequent survey at this service, from 2011 to 2019, the number of AC diagnoses increased to 87 cases (16). This study shows a continuous increase, totaling 136 patients with a clinical diagnosis of AC. Notably, the number of military personnel diagnosed with AC and CCEL (83.1% and 75.0%, respectively) substantially exceeded that of military relatives (16.9% and 25%, respectively).

A study by Penoni *et al*. (32) about the profile of patients treated at the OCM indicated a significantly higher percentage of military relatives compared to military personnel. However, our study suggests a higher rate of military participants with AC. The result also reinforces that most of these patients were almost exclusively at risk of occupational sun exposure since only 15 (16.9%) practiced outdoor sports/leisure. This suggests that occupational sun exposure in military personnel plays a fundamental role in the development of AC and that other preventive measures should be adopted to avoid the onset and progression of this MPD. The number of Navy personnel with AC and CCEL reported in this study is much higher than that reported in the literature for a similar population and/or occupational factor (33,34). A cross-sectional study of 395 military police officers in a southeastern Brazilian city assessing the frequency of oral injuries found only two participants with AC and no cases of SCC.

Cigic *et al*. (33), also carried out a cross-sectional study of the frequency of oral injuries in 102 military veterans from Croatia, diagnosing two cases of AC and one of SCC. Although the comparison between these studies and the work described here is not ideal, due to the small sample and their different scopes, these are the only ones in the literature dedicated to the civilians (represented by the military relatives) and the military personnel. This difference in results may be due to the easier access to dental care within MB and its PSBs, increasing the total number of dental appointments and possibly the number of diagnoses of AC by the Stomatology Clinic.

On the other hand, this study found no statistically significant association between occupational status and the severity of OED.

The clinical profile of patients who develop AC reported in the literature that the main area affected is the lower lip; white individuals between the fourth and fifth decade of life and who have been exposed to the sun for long periods during their lives can also be observed in the clinical and demographic profile of this sample, since it was observed that the most affected anatomical area was the lower lip, the majority were white (85.4%) and military veterans (68.5%), individuals over the age of 45, with soldiers from operative divisions being more affected than officers (7,20,24). It is well known that enlisted perform more executive functions than officers, who mostly perform strategic administrative and planning functions. This leads them to carry out more operational duties outdoors and consequently with more frequent exposure to the sun, making them the most exposed occupational profile.

SCC also has a predilection for the lower lip in white men between 60 and 70 (7,20,35). Chronic exposure to UV rays is its main risk factor, and it is associated with drinking and smoking habits, so the risk of developing this neoplasm increases considerably (6,7,10,35,36). These data are similar to those observed in the results of this study since all the cases affected the lower lip, with the majority (75%) being men and smoking and drinking habits being observed in 62.5% of the cases.

Riemenschneider *et al*. (19), in their systematic review, found that there is substantial evidence to suggest a high risk of developing melanoma and non-melanoma skin cancer in the military, lesions which, like SCC, have similar risk factors, and showed that the incidence rate in the military is higher when compared to the general population, from the age of 45 and especially in the 55 and 60 age group. In this study, the age group that includes the over-50s represents 87.5% of the sample and is within the range reported for the military population in previous studies. However, we observed a case of an active-duty military man, a seaman, who was only 29 years old and diagnosed with SCC. Cases like this demonstrate the need to intensify educational and preventive measures, also focusing on younger people.

CONCLUSION

The data on individuals with AC and SCC diagnosed by the OCM Stomatology Clinic reported here agree with the results of case series and retrospective studies reported elsewhere on the occupational factor. On the other hand, they show that the PSB and the periodic follow-up of patients with AC, carried out in the Brazilian Navy, play an important role in the management of this lesion and can delay or even prevent the appearance of SCC in this population with a military occupational risk factor, when patients are made aware and have access to a specialized stomatology service.

The authors declare that there is no conflict of interest.

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REFERENCES

1. Romagna DV, Oliveira MMD, Abreu LG, Stein C, Hugo FN, Teixeira R, *et al*. Incidence and mortality rates of lip, oral cavity, and pharynx cancers in Brazil: time-trend and age-period-cohort analysis from the last 30 years. Global Burden of Disease Study. Rev Soc Bras Med Trop. 2022;55(Suppl 1):e0286-2021.
2. Alshami ML, Al-Maliky MA, Alsagban AA, Alshaeli AJ. Epidemiology and incidence of oral squamous cell carcinoma in the Iraqi population over 5 years (2014–2018). Health Sci Rep. 2023 Jul 25;6(4):e1205.
3. Du M, Nair R, Jamieson L, Liu Z, Bi P. Incidence Trends of Lip, Oral Cavity, and Pharyngeal Cancers: Global Burden of Disease 1990–2017. J Dent Res. 2020 Feb 1;99(2):143-51.
4. Ling Z, Cheng B, Tao X. Epithelial-to-mesenchymal transition in oral squamous cell carcinoma: Challenges and opportunities. Int J Cancer. 2021;148(7):1548-61.
5. Mattos MV, Honorato J, de Assumpção Leite AFS, de Oliveira SP, Lourenço S de QC. Queilite actínica ("Lábios de Marinheiro"): uma Revisão para o Clínico. RNO. 2023;50(2):39-45.
6. de Oliveira Santos M, de Lima FC da S, Martins LFL, Oliveira JFP, de Almeida LM, de Camargo Cancela M. Estimativa de incidência de câncer no Brasil, 2023-2025. RBC. 2023;69(1) (accessed on Oct 8th, 2023). Available at: https://rbc.inca.gov.br/index.php/revista/article/view/3700.
7. Silva LV de O, de Arruda JAA, Abreu LG, Ferreira RC, da Silva LP, Pelissari C, *et al*. Demographic and Clinicopathologic Features of Actinic Cheilitis and Lip Squamous Cell Carcinoma: a Brazilian Multicentre Study. Head Neck Pathol. 2020 Dec;14(4):899-908.
8. Bakirtzi K, Papadimitriou I, Andreadis D, Sotiriou E. Treatment options and post-treatment malignant transformation rate of actinic cheilitis: a systematic review. Cancers. 2021;13(13):3354.
9. Markopoulos A, Albanidou-Farmaki E, Kayavis I. Actinic cheilitis: clinical and pathologic characteristics in 65 cases. Oral Dis. 2004;10(4):212-6.
10. Lopes MLD de S, Silva Júnior FL da, Lima KC, Oliveira PT de, Silveira ÉJD da. Clinicopathological profile and management of 161 cases of actinic cheilitis. An Bras Dermatol. 2015;90(4):505-12.
11. Piñera-Marques K, Lorenço SV, Silva LFF da, Sotto MN, Carneiro PC. Actinic lesions in fishermen's lower lip: clinical, cytopathological and histopathologic analysis. Clinics (Sao Paulo). 2010 Apr;65(4):363–7.
12. Rodriguez-Blanco I, Florez A, Paredes-Suarez C, Rodriguez-Lojo R, Gonzalez-Vilas D, Ramirez-Santos A, *et al*. Actinic cheilitis prevalence and risk factors: a cross-sectional, multicentre study in a population aged 45 years and over in north-west Spain. Acta dermato-venereologica. 2018;98(10):970-4.
13. de Oliveira Ribeiro A, da Silva LCF, Martins-Filho PRS. Prevalence of and risk factors for actinic cheilitis in Brazilian fishermen and women. Int J Dermatol. 2014 Nov;53(11):1370-6.
14. Vasilovici A, Ungureanu L, Grigore L, Cojocaru E, Şenilă S. Actinic Cheilitis - From Risk Factors to Therapy. Front Med (Lausanne). 2022 Feb 15;9:805425.
15. Lupu M, Caruntu A, Caruntu C, Boda D, Moraru L, Voiculescu V, *et al*. Non-invasive imaging of actinic cheilitis and squamous cell carcinoma of the lip. Mol Clin Oncol. 2018 May;8(5):640-6.
16. Miranda AMO, Soares LG, Ferrari TM, Silva DG, Falabella MEV, Tinoco EMB. Prevalence of actinic cheilitis in a population of agricultural sugarcane workers. AOL. 2012 Oct;25(2):201-7.

17. Macedo JC. Incidência de queilite actínica em militares da ativa/inativos atendidos na clínica na clínica de estomatologia da Odontoclínica Central da Marinha: uma proposta de intervenção. Rio de Janeiro. [Trabalho de Conclusão de Curso - Odontologia] – Marinha do Brasil; 2020.
18. Boldes IP, de Azevedo AB, da Cunha Macedo J, Silami MANC, Penoni DC, de Carvalho Andrade MA. Queilite actínica: análise retrospectiva de 29 casos da Clínica de Estomatologia da Odontoclínica Central da Marinha. RNO. 2016;43(1) (accessed on Oct 6th, 2023). Available at: http://portaldeperiodicos.marinha.mil.br/index.php/odontoclinica/article/view/16.
19. Riemenschneider K, Liu J, Powers JG. Skin cancer in the military: A systematic review of melanoma and nonmelanoma skin cancer incidence, prevention, and screening among active duty and veteran personnel. J Am Acad Dermatol. 2018 Jun;78(6):1185-92.
20. Mello FW, Melo G, Modolo F, Rivero ERC. Actinic cheilitis and lip squamous cell carcinoma: Literature review and new data from Brazil. J Clin Exp Dent. 2019 Jan 1;11(1):e62-9.
21. Wolf ST, Kenney LE, Kenney WL. Ultraviolet Radiation Exposure, Risk, and Protection in Military and Outdoor Athletes. Curr Sports Med Rep. 2020 Apr;19(4):137-41.
22. Powers JG, Patel NA, Powers EM, Mayer JE, Stricklin GP, Geller AC. Skin cancer risk factors and preventative behaviors among United States military veterans deployed to Iraq and Afghanistan. J Invest Dermatol. 2015;135(11):2871-3.
23. Lea CS, Efird JT, Toland AE, Lewis DR, Phillips CJ. Melanoma incidence rates in active duty military personnel compared with a population-based registry in the United States, 2000–2007. Mil Med. 2014;179(3):247-53 (Accessed on Dec 24st, 2023). Available at: https://academic.oup.com/milmed/article-abstract/179/3/247/4160738.
24. Medeiros CK, Lopes ML, Silveira ÉJ, Lima KC, Oliveira PT. Actinic cheilitis: Proposal of a clinical index. Med Oral Patol Oral Cir Bucal. 2022 Jul 1;27(4):e310-8.
25. de Castro Abrantes T, Fonsêca TC, Cabral MG, Agostini M, Benevenuto de Andrade BA, Romañach MJ, *et al*. Epithelial Dysplasia in Actinic Cheilitis: Microscopic Study of 70 Cases from Brazil. Head Neck Pathol. 2021 Jun;15(2):566-71.
26. de Azevedo AB, Dos Santos TCRB, Lopes MA, Pires FR. Oral leukoplakia, leukoerythroplakia, erythroplakia and actinic cheilitis: Analysis of 953 patients focusing on oral epithelial dysplasia. J Oral Pathol Med. 2021 Sep;50(8):829-40.
27. El-Naggar AK, Chan JKC, Grandis JR, Takata T, Slootweg PJ. WHO Classification of Head and Neck Tumours. 2017 (Accessed on Dec 24th, 2023). Available at: https://publications.iarc.fr/Book-And-Report-Series/Who-Classification-Of-Tumours/WHO-Classification-Of-Head-And-Neck-Tumours-2017.
28. Brasil. Lei Nº 6.880, de 9 de dezembro de 1980. Dispõe sobre o Estatuto dos Militares. Diário Oficial da União 9 de dez 1980 (Accessed on Mar 10th, 2024). Available at: https://www.planalto.gov.br/ccivil_03/leis/l6880.htm.
29. Kujan O, Oliver RJ, Khattab A, Roberts SA, Thakker N, Sloan P. Evaluation of a new binary system of grading oral epithelial dysplasia for prediction of malignant transformation. Oral Oncol. 2006 Nov;42(10):987-93.
30. Talon LSM. Saúde bucal programa de saúde bucal na Marinha: em busca de uma atitude preventiva nos usuários do sistema de saúde da Marinha. Trabalho de Conclusão de Curso [Graduação em Odontologia] – Marinha do Brasil; 2011.
31. Paulino JNV. Prevalência de queilite actínica e fatores associados: uma revisão sistemática. Trabalho de Conclusão de Curso [Graduação em Odontologia] – Universidade Federal do Rio Grande do Norte; 2015 (Accessed on Oct 7th, 2023). Available at: https://repositorio.ufrn.br/handle/123456789/39172.
32. Penoni DC, Carlos JC, Santos IAR dos, Baptista L da S, Souza EB de, Leão ATT. O perfil clínico e demográfico do paciente assistido pela Odontoclínica Central da Marinha e o papel do cirurgião-dentista na atenção integral à saúde. RNO. 2018;45(1) (Accessed on Dec 21st, 2023). Available at: https://www.portaldeperiodicos.marinha.mil.br/index.php/odontoclinica/article/view/https%3Adoi.org10.2932725149.45.1.
33. Cigic L, Martinovic D, Martinic J, Kovic M, Druzijanic A, Galic I, *et al*. Increased prevalence of oral potentially malignant lesions among Croatian War invalids, a cross-sectional study. J Clin Exp Dent. 2023 Sep;15(9):e734-41.
34. Araújo VS, Godinho EL, Farias LC, Marques-Silva L, Santos SHS, Rodrigues-Neto JF, *et al*. Prevalence of oral mucosal lesions in a brazilian military police population. J Clin Exp Dent. 2015 Abr 1;7(2):e208-11.
35. Souza LR, Fonseca Fonseca T, Oliveira Santos CC, Corrêa GTB, Santos FBG, Cardoso CM, *et al*. Lip squamous cell carcinoma in a Brazilian population: epidemiological study and clinicopathological associations. Med Oral Patol Oral Cir Bucal. 2011 Sep 1;16(6):e757-62 (Accessed on Jan 2nd, 2024]. Available at: https://roderic.uv.es/handle/10550/60091.
36. Narayanan DL, Saladi RN, Fox JL. Review: Ultraviolet radiation and skin cancer. Int J Dermatology. 2010 Sep;49(9):978-86.

CASE REPORT

EVALUATION OF THE EFFECTIVENESS OF DIFFERENT RESTORATIVE APPROACHES IN PATIENTS WITH MOLAR INCISOR HYPOMINERALIZATION: A TWELVE-MONTH FOLLOW-UP

AVALIAÇÃO DA EFICÁCIA DE DIFERENTES ABORDAGENS RESTAURADORAS EM PACIENTE COM HIPOMINERALIZAÇÃO MOLAR INCISIVO: UM ACOMPANHAMENTO DE DOZE MESES

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ABSTRACT

Molar Incisor Hypomineralization (MIH) is a systemic enamel developmental defect characterized by enamel opacities affecting one or more permanent first molars, with or without the involvement of one or more incisors. The major challenge in restorative treatment is related to the adhesion of adhesive systems to the MIH-affected dental substrate. This study aims to report different approaches to restorative treatments that were adopted for teeth affected by MIH in the same patient. A 14-year-old male caucasian patient came to the Odontoclínica Central da Marinha (OCM, Marinha do Brasil, Rio de Janeiro, Brazil) with complaints of dental sensitivity and esthetics presented extensive opaque white, beige, and brown stain on the upper right incisor and upper right and left first molars. Both molars were previously restored and the left molar was infiltrated by caries. The rapid progression of this condition prompted the replacement of restorations, emphasizing the importance of continuous monitoring. Conservative direct composite resin restorations with intact enamel margins, as seen in upper right incisor, proved effective after 12 months of follow-up. Cavities, where the MIH lesion was not completely removed from the margin, had unsuccessful restorations and required re-intervention, with replacement of deficient restorations in upper right and left first molars after removal of affected enamel. This case highlights the importance of clinical knowledge and correct diagnosis of MIH lesions.

Keywords: MIH; Composite resin; Dental enamel; Enamel developmental defects; Dental enamel hypomineralization.

RESUMO

A Hipomineralização Molar Incisivo (HMI) é um defeito do desenvolvimento do esmalte, de origem sistêmica, que se caracteriza pela presença de manchas no esmalte afetando um ou mais primeiros molares permanentes, com ou sem envolvimento de um ou de mais incisivos. O maior desafio no tratamento restaurador está relacionado à adesão dos sistemas adesivos ao substrato dentário afetado pela HMI. O objetivo deste estudo é relatar as diferentes abordagens de tratamentos restauradores que podem ser adotadas para dentes afetados pela HMI. Paciente jovem, com queixa de sensibilidade dentária e estética, apresentando os dentes 11, 26 e 36 com manchas opacas extensas, de cor branca, bege e marrom, sendo os dentes 26 e 36 previamente restaurados, e o dente 26 infiltrado por cárie. A rápida progressão desse quadro motivou a substituição das restaurações, reforçando a importância do monitoramento contínuo. Restaurações em resina composta direta, de forma conservadora, com bordas em esmalte sadio, como a do dente 11, mostraram-se eficientes após 12 meses de acompanhamento. Cavidades onde a lesão por HMI não foi totalmente removida da margem, tiveram restaurações malsucedidas e necessitaram reintervenção, com a realização da troca das restaurações deficientes dos dentes 26 e 36, após remoção do esmalte afetado. Este caso demonstrou a importância do conhecimento clínico e do diagnóstico correto das lesões por HMI.

Palavras-chave: HMI; Resina composta; Esmalte dentário; Defeitos de desenvolvimento do esmalte dentário; Hipomineralização do esmalte dentário.

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INTRODUCTION

Molar Incisor Hypomineralization (MIH) is an enamel development defect of systemic origin characterized by enamel defects affecting one or more permanent molars, with or without the involvement of one or more incisors (1–3). The incidence of enamel defects affecting only one permanent molar is 24.3%, 26.8% for the first four permanent molars affected, and 42.1% of cases involving both permanent molars and incisors (4). The defect occurs during the mineralization of tooth enamel and can result in opacity on the tooth surface, with colors ranging from white/yellow to brown (2). The enamel shows a qualitative deficiency, becoming porous and with opaque stains, which facilitates the occurrence of post-eruptive fracture, hypersensitivity, plaque accumulation, and the progression of caries lesions (1,3,5–8). The exact etiology of MIH has not yet been fully clarified. Still, it may be associated with environmental factors that coincide with the period of maturation of the organic matrix of molar and incisor enamel, such as complications during childbirth, premature birth, low birth weight, jaundice, antibiotic use, ear and respiratory infections, high fever, hypoxia, inhaled asthma medication, vitamin D deficiency, as well as genetic factors that have been much debated by science (1,2,9–13).

Various treatments are described in the literature for teeth affected by MIH to improve signs, aesthetics, morphology, and function (9,14–17). A multidisciplinary approach may be necessary for prevention and intervention (9,14–17). The treatment choice depends on the severity of the condition in the affected tooth, the patient's age, the signs presented, and the aesthetic expectations (3,9,14–17). The earlier the diagnosis, the more effective the preventive measures will be, avoiding deleterious consequences such as the rapid progression of caries, pain, or invasive treatments (18). In addition to conservative preventive treatments, such as caries prevention and tooth remineralization, other minimally invasive treatments can be considered, such as enamel micro-abrasion and low-viscosity resin infiltration, or invasive treatments such as direct glass ionomer cement or composite resin restorations and indirect composite resin, ceramic or metal restorations, as well as the possibility of tooth extraction (9,14–17).

The greatest challenge in the restorative treatment of this condition is related to the bonding of adhesive systems to the dental substrate affected by MIH (19). The increased porosity of enamel results in a reduction in its hardness and elasticity (3). In addition, the disorganization of hydroxyapatite crystals, decreased mineral content, and increased protein content contribute to unfavorable adhesion (20). The different types of adhesive systems available so far, whether self-etch or total-etch, have not yet demonstrated adequate adhesion to affected enamel (21,22). The dentin below the affected enamel exhibits lower mineral density and increased interglobular or hypomineralized dentin. However, adhesion to this tissue is not impaired (19). Scientific literature suggests removing the enamel affected by MIH to maximize adhesion, leaving the restoration margins in healthy enamel (19,23).

In this context, this case report aims to describe the different treatment approaches for MIH at different stages, ranging from conservative composite resin restorations, including proservation and 12-month longitudinal follow-up, to the need for reintervention through direct and indirect restorations.

CASE REPORT

A 14-year-old male caucasian patient with no systemic health problems came to the Odontoclínica Central da Marinha (OCM, Marinha do Brasil, Rio de Janeiro, Brazil), accompanied by his guardian, for evaluation of the upper left first molar due to extensive restoration and sensitivity. During the clinical examination, an orthodontic band covering the tooth was identified, along with beige and brown stains and a composite resin restoration infiltrated by caries (figure 1-D). The patient reported sensitivity to cold, and during chewing, an orthodontic band was fitted a few years ago to prevent a tooth fracture. Other teeth with stains were evaluated, such as upper right incisor, upper right first molar, lower right and left first molars, lower left and right lateral incisor (figure 1-B, C, E, F). The upper right incisor had a localized beige, yellow, and brown stain on the buccal surface, causing aesthetic dissatisfaction for the patient, who avoided smiling, affecting his quality of life (figures 1-A and B). Although there were other affected teeth, the upper left first molar and the upper right incisor were the most compromised, whether due to the extent of the restoration, sensitivity, or aesthetic reasons.

During the anamnesis, the person in charge reported that the patient's mother had pre-eclampsia during pregnancy, which resulted in a premature birth and the baby being kept in an incubator for two days. During early childhood, the patient had frequent episodes of fever due to respiratory infections, leading to frequent use of antibiotics. The diagnosis of MIH was confirmed based on the medical history and clinical analysis.

Initially, intraoral and extraoral photographs, digital periapical radiographs, and transillumination of the upper right incisor were taken using the Valo® light-curing device (Ultradent, Utah, United States). The treatment plan proposed a direct composite

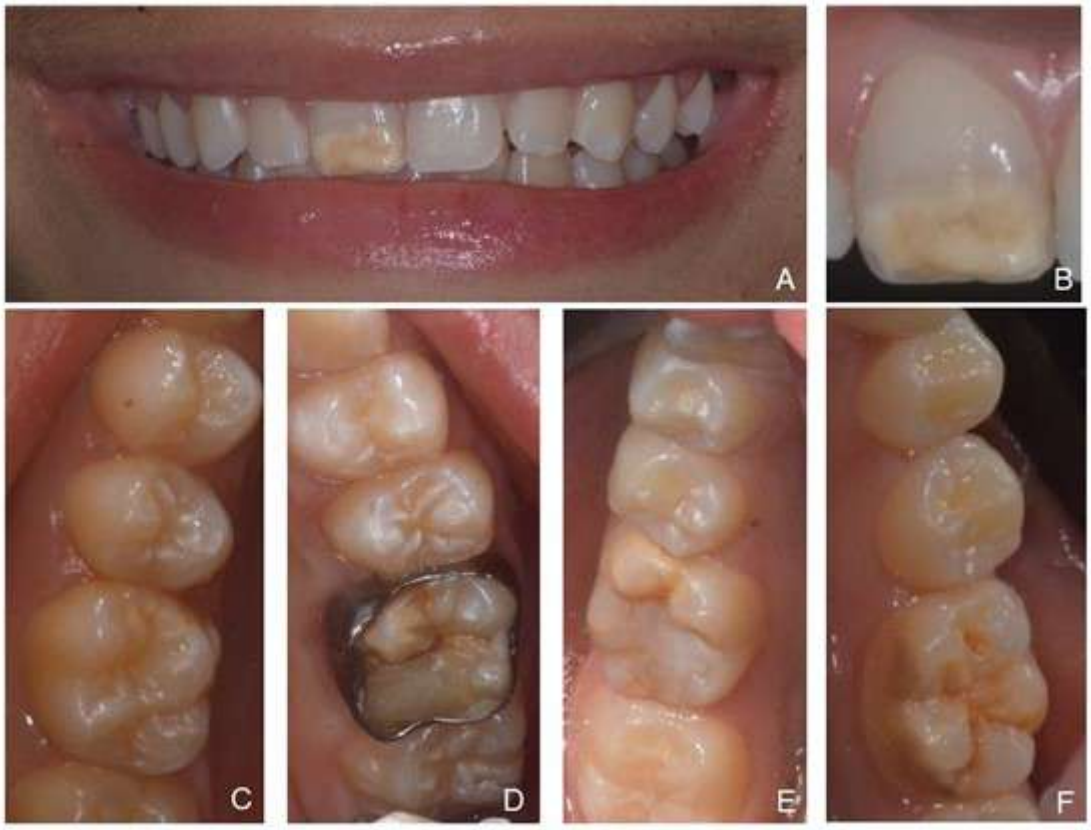

Figure 1. *A) Patient's smile. B) Close-up view of upper right incisor, showing an opaque beige, yellow, and brown stain. C) Upper right molar. D) Upper left molar surrounded by a metal band, with composite resin restoration and beige and brown opaque stains. E) Lower left molar with satisfactory composite resin restoration. F) Lower right molar showing beige and brown opaque stains.*

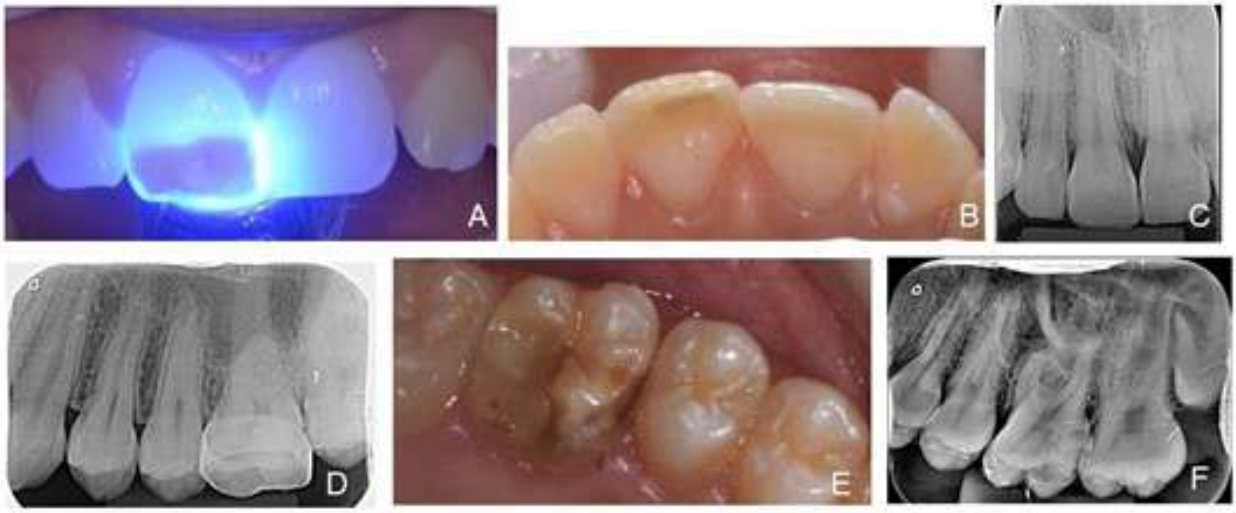

Figure 2: *Clinical and radiographic evaluation. A) Transillumination of upper right incisor using Valo® light-curing unit; B) Palatal view of upper right incisor, showing the opaque beige stain also in this region; C) Radiograph of upper right incisor. D) Radiograph of tooth upper left molar before removal of the metal band; E) Upper left molar with extensive composite resin restoration infiltrated by caries, presence of beige and brown opaque stains, after removal of the metal band. F) Radiograph of upper left molar after removal of the metal band.*

resin restoration for this tooth, considering the patient's age and expectations and the severity of the MIH lesion observed using transillumination (figure 2-A). For the upper left first molar, the proposal included the removal of the orthodontic band, the infiltrated restoration, and the selective removal of caries, followed by direct restoration in composite resin (figure 2-D, E, F). The other teeth would be preserved, with special attention to the lower left first molar (figure 1-E), and reassessed after 12 months.

The legal caregiver signed the Informed Consent Form (ICF), and the patient signed the Assent Form. After completing the treatment, the case report was submitted to the Research Ethics Committee of the Marcílio Dias Naval Hospital and approved with a protocol number 6.808.155.

The composite resin colors for the upper right incisor were selected employing small increments light-cured with the Valo® device on the tooth surface of the homologous tooth, providing greater predictability. Forma® resins (Ultradent, Utah, United States) in shades A2D and Incisal, as well as Z350XT® (3M ESPE, Minnesota, United States) in shade A2E, were chosen for the procedure (figure 3-B).

The upper right incisor was prepared by removing the enamel affected by MIH so that the edges of the restoration were in healthy tissue (6,24). Dental diamond burs (References 1014 and 4138, KG Sorensen, São Paulo, Brazil) were used for tooth preparation. Rubber dam was then performed (figure 3-D), followed by asepsis of the preparation with a Robinson brush (Microdont, São Paulo, Brazil) and 2% chlorhexidine gluconate paste Consepsis Scrub (Ultradent, Utah, United States) (figure 3-E). In the restorative procedure, total acid etching was carried out with 37% phosphoric acid Ultra-Etch (Ultradent, Utah, United States) for 30 seconds on enamel and 15 seconds on dentin (figure 3-F), followed by rinsing with water and drying. The Adper® Scotchbond® Multipurpose adhesive system (3M ESPE, Minnesota, United States) was used for the adhesive layer, according to the manufacturer's instructions, and light-cured with the Valo® device for 20 seconds. Insertion of the composite resin began with colors A2D and A1B Forma®, 0.9mm thick (figure 3-H), to simulate dentin and mask the unremoved opaque stain. The WE shade of Palfique® XL5 resin was used to simulate tooth enamel on the proximal and buccal sides, with a thickness of 0.3 mm. At the end of the restoration, the initial finishing was done with fine and extra fine-grained diamond burs (References 3195 F and FF, KG Sorensen) (figure 3-I).

Subsequently, the orthodontic band was removed from the upper left first molar (figure 2-E), followed by a new digital periapical radiograph (figure 2-F), enabling a better assessment of the extent of the caries lesion below the restoration. Infiltrative anesthesia was performed with a tube of 2% Lidocaine with 1:100000 adrenaline - Alphacaine. The deficient restoration was removed with a spherical diamond bur at high speed (Reference 1014, KG Sorensen) and selective caries removal with a spherical carbide drill (Reference nº5, KG Sorensen) at low speed. During the removal of decayed tissue, pulp exposure occurred, and a pulpectomy was performed. The patient was referred to the Endodontics Clinic (OCM, Marinha do Brasil, RJ), where the endodontic treatment was completed in a single session (figure 4-B). To continue treatment at the Restorative Dentistry Clinic, the provisional restoration was removed with a spherical diamond bur at high speed (Reference 1014, KG Sorensen) (figure 4-C), followed by rubber dam. The palatal and distal walls, which were weakened, were included in the cavity preparation, as was the tissue affected by MIH. The Omni-matrix® metal matrix (Ultradent, Utah, USA) was adapted to shape the restoration, followed by total acid etching with 37% phosphoric acid Ultra-Etch, rinsing with water, and drying. The adhesive layer was applied using the Adper® Scotchbond® Multiuso adhesive system, as indicated by the manufacturer.

Figure 3. *Direct composite resin restoration of upper right incisor. A) Initial state of the tooth; B) Shade matching on upper left incisor using small increments of light-cured composite resin on the tooth surface, without the use of adhesive system; C) 6mm wide metal matrix positioned to start preparation with burs on upper right incisor; D) upper right incisor after preparation with burs with partial removal of the lesion by HMI, and installation of rubber dam isolation; E) Preparation prophylaxis; F) Polyester matrix positioned to protect neighboring teeth during phosphoric acid application; G) Application of adhesive system with microbrush; H) After application and light-curing of the dentin layer of composite resin; I) Final aspect of the restoration on upper right incisor.*

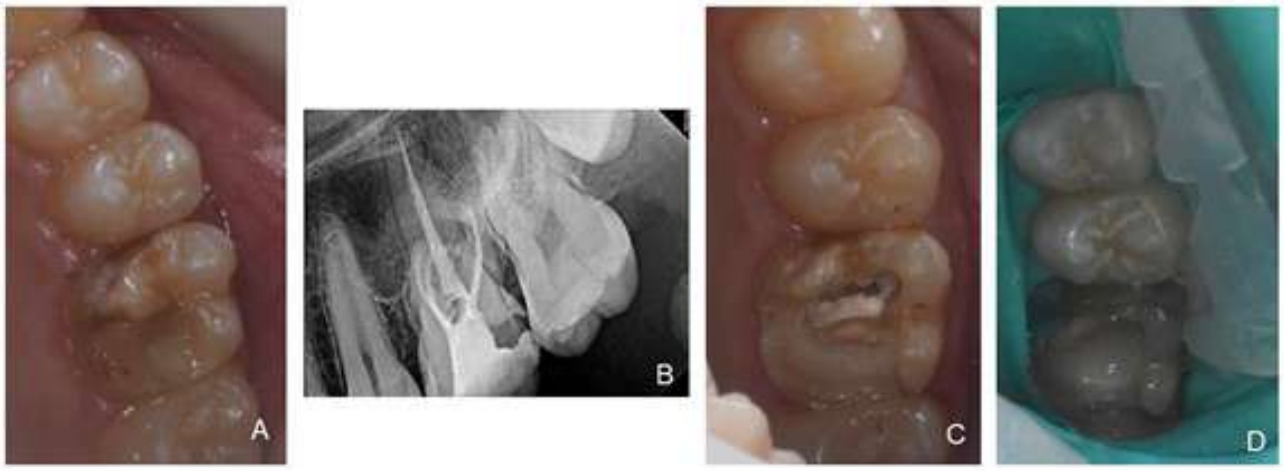

Figure 4. *Composite resin restoration of the upper left first molar. A) Initial state of the upper left first molar after removal of the metal band; B) Radiograph after endodontic treatment; C) After endodontic treatment, removal of temporary restoration and cavity preparation-with burs; D) The upper left first molar with rubber dam isolation and metal matrix to shape the walls, during restorative procedure.*

and light-cured with the Valo® device for 20 seconds. In the restoration, the palatal, distal, and occlusal walls were reconstructed with Forma® composite resin in A3E color, simulating tooth enamel, with a thickness of approximately 1mm (figure 4-D). For the dentin portion, Flow Opallis color A2 (FGM, Santa Catarina, Brazil) composite resins were used to seal the entrance to the ducts, and Bulk Fill Opallis color A3 (FGM, Santa Catarina, Brazil). Each increment was light-cured with a Valo® appliance according to the manufacturer's instructions. After removing the rubber dam, occlusal adjustment was carried out, followed by occlusal and proximal finishing.

Both restorations were finished using Sof-Lex® polishing strips and a Sof-Lex® Pop-on abrasive disk (3M ESPE, Minnesota, USA). Polishing was achieved using abrasive rubber tips impregnated with Jiffy® silica (Ultradent, Utah, USA), Diamond felt discs, Diamond AC I and II polishing paste (FGM, Santa Catarina, Brazil), and a goat hair brush for the contra-angle (American Burrs, USA).

After completing the restorative procedures on teeth upper right incisor and upper left incisor, significant improvements in smile aesthetics and masticatory function were achieved. The aesthetic impact of upper right incisor was remarkable for the patient and his guardian, who expressed great satisfaction with their new smile. Besides, the restoration of upper left molar contributed to a significant improvement in masticatory function with a reduction in sensitivity.

During the follow-up appointment, which took place 12 months after the procedure, the color, shape, and marginal integrity of the direct composite resin restoration in element upper right incisor were maintained (figure 5-A). However, upper left molar showed marginal maladaptation on the distal face, with no obvious caries activity (figure 5-C), as confirmed by digital periapical radiography (figure 5-B) and clinical evaluation with an exploratory probe, and an indirect restoration was indicated. Of the elements initially indicated for follow-up, only lower left molar, also affected by MIH, required restoration replacement due to the fracture associated with the adjacent caries lesion (Figures 5-D and E).

In upper left molar, the pre-existing restoration was partially removed, and an overlay preparation was made using dental diamond burs (Reference 4138, 4138F, 3131, and 3131F, KG Sorensen) (figure 6-A). The preparation was finished with a Soft-Lex® Pop-on finishing disc in red and orange, followed by abrasive rubber tips silica impregnated Jiffy in green and yellow. Next, retractor wire #00 Ultrapak (Ultradent, Utah, United States) was inserted and scanned with the CEREC Omnicam intraoral scanner (Dentsply Sirona, Charlotte, United States). The indirect restoration was designed using CEREC 4.1 software (Dentsply Sirona, Charlotte, USA) on the virtual model and milled using the InLab MC XL milling machine (Dentsply Sirona, Bensheim, Germany) in a CEREC Blocs C PC 14 polychromatic feldspathic ceramic block (Dentsply Sirona, Charlotte, USA) in color A3. After testing the indirect restoration, the prosthetic restoration was prepared for resin cementation. 10% hydrofluoric acid Condac porcelain (FGM, Santa Catarina, Brazil) was applied for 2 minutes, rinsed with air and water jet, and dried with air jet. Prosil silane (FGM, Santa Catarina, Brazil) was applied to the inside of the piece and volatilized with air jets after 1 minute. The tooth was relatively isolated using a dental sucker, cotton rollers, and Teflon tape, rinsed with a jet of air

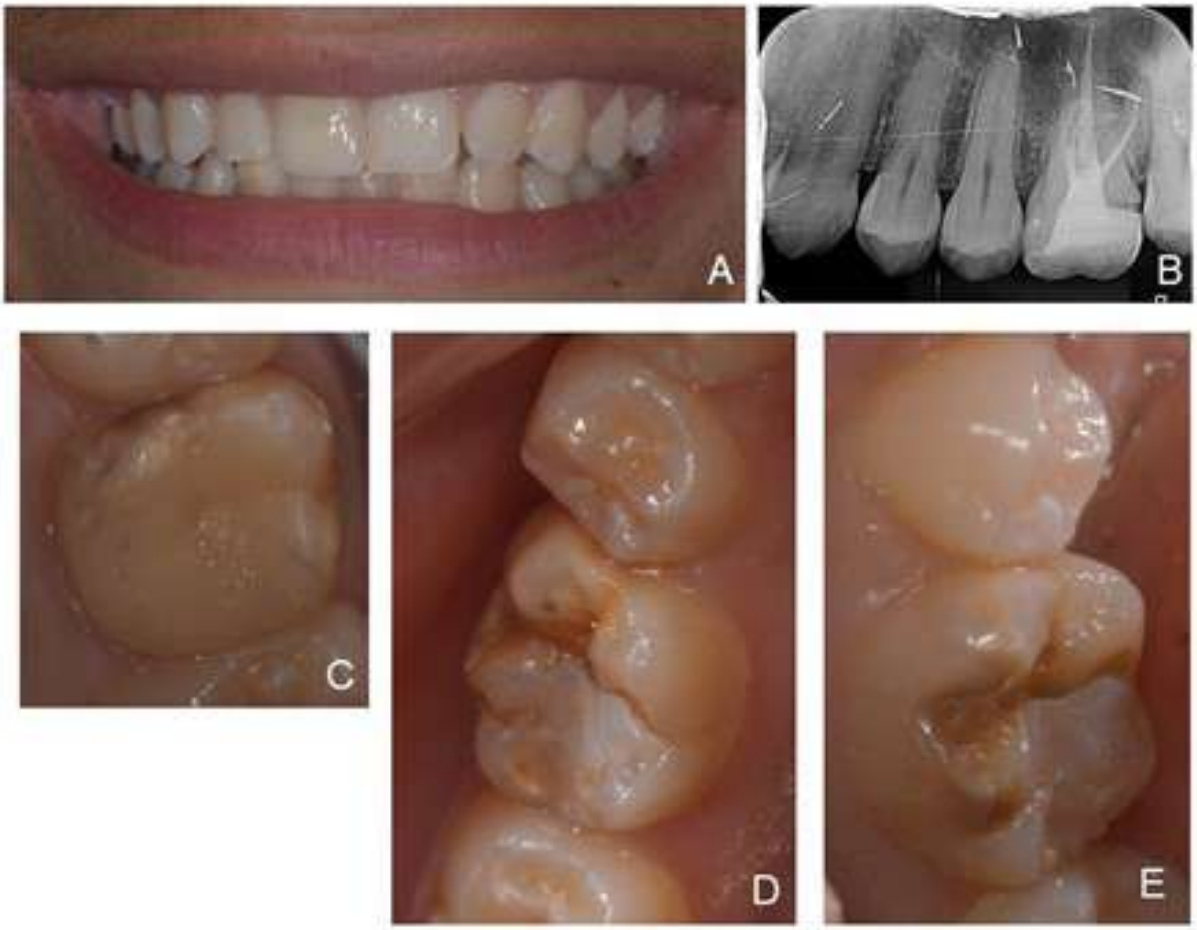

Figure 5. *Reevaluation after 12 months of initial treatment. A) Patient's smile showing upper right incisor restoration in excellent condition; B) Radiograph of upper left molar, where misfit is observed on the distal aspect of the composite resin restoration; C) Clinical aspect of upper left molar; D and E) lower left molar in occlusal-lingual and vestibular views, respectively. Fracture of restoration edges and caries infiltration are observed.*

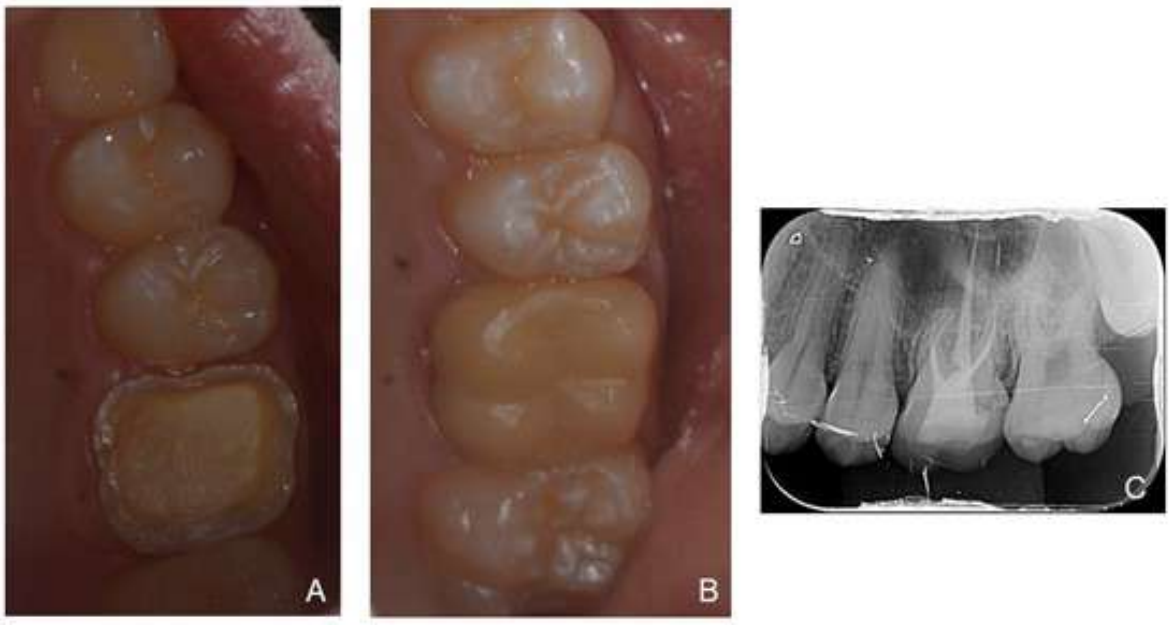

Figure 6. *Ceramic indirect restoration of upper left molar. A) Partial removal of misfit composite resin restoration and preparation for ceramic crown; B) Final aspect of cemented ceramic crown; C) Radiographic aspect after cementation of ceramic crown.*

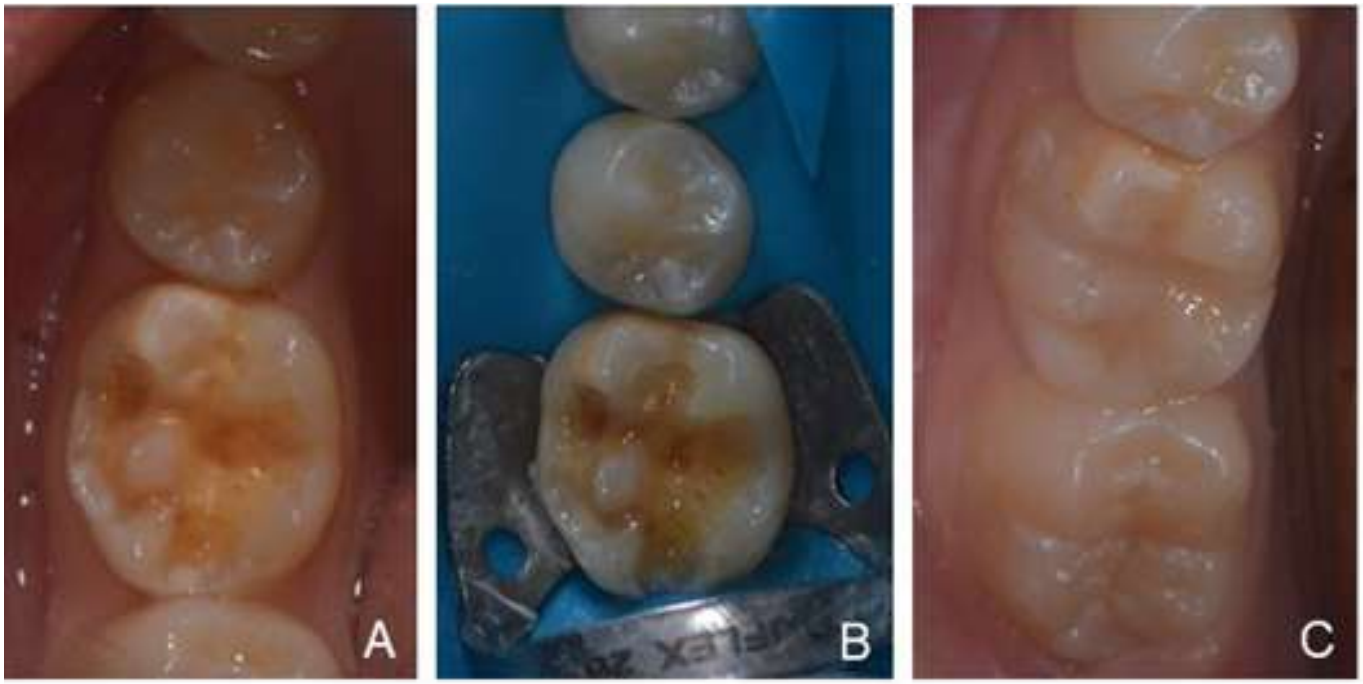

Figure 7. *Restoration of lower left molar. A) After removal of fractured restoration, caries lesion, and tissue affected by HMI; B) Rubber dam isolation installed and application of adhesive system; C) Clinical aspect of completed restoration on lower left molar.*

and water, and jets of air. Silane was then applied to the core filling area, followed by cementation of the indirect restoration with RelyX U200 dual-curing self-adhesive cement (3M ESPE, Minnesota, United States) in shade OA3. The cement was photoactivated for 1 minute on each side using the Gran Valo® photoactivator (Ultradent, Utah, United States). Subsequently, the relative isolation and marginal excesses of resin cement were removed using finely tapered diamond tips (Reference 2200F, KG Sorensen), a abrasive strip Microcut (TDV, Paraná, Brazil), and a #12 scalpel blade. Occlusal adjustment, finishing, and polishing were carried out with sequential rubber abrasive tips impregnated with silicon carbide (DhPro, Paraná, Brazil), followed by the final radiograph (Figures 6-B and C). Despite the difference in the color of the indirect restoration compared to the other teeth, the patient was satisfied with the prosthetic crown installed.

The infiltrated restoration of lower left molar was removed with a spherical diamond bur (Reference 1014, KG Sorensen), as well as the decayed tissue, using a spherical drill at low speed (Reference nº4 and 5, KG Sorensen). The area of enamel and dentin affected by MIH was also removed so that the edges of the cavity preparation remained in healthy tissue (figure 7-A). After rubber dam, a polyester matrix was adapted, followed by a total acid attack with 37% phosphoric acid, washed with water, and dried. The Adper® Scotchbond® Multipurpose adhesive system was applied according to the manufacturer's instructions and light-cured with the Valo® device for 20 seconds (figure 7-B). In the restoration, the buccal, distal, and occlusal walls were reconstructed with Z350XT composite resin in color A1E, simulating tooth enamel with a thickness of approximately 1mm. The dentin was mimicked using Forma® composite resin in the color A2D, and each increment of resin was photoactivated for 20 seconds and then for a further 1 minute on each side. After removing the rubber dam, occlusal and proximal adjustment was carried out, followed by finishing with abrasive rubber tips silica impregnated Jiffy in green, yellow, and white, followed by the silicon carbide brush Ultra-Brush (American Burrs, United States) (figure 7-C).

DISCUSSION

This case report describes the restorative treatment of teeth affected by MIH using direct and indirect adhesive restorations. After removal of the restoration, enamel affected by MIH, and decayed tissue, endodontic treatment was required on upper left molar. The initial decision was to use direct composite resin restoration techniques on this tooth and on teeth upper right incisor and lower left molar to achieve a more conservative treatment. However, due to the difficulty in adhering to the tissue affected by MIH, adhesive failure was observed on the distal proximal face of the restoration on upper left molar. Given this circumstance, we opted for indirect restoration in the reintervention after removing the area of enamel affected by MIH, given the extensive loss of structure. In the case of lower left molar, which initially had a satisfactory composite resin

restoration, there was an unfavorable evolution marked by fracture of the restoration associated with a caries lesion. Teeth affected by MIH are more prone to post-eruptive fracture, facilitated caries lesion progression (3,5), and unfavorable enamel bonding (19,20). These conditions progressed rapidly in upper left molar and lower left molar, culminating in the need to replace the composite resin restorations in these teeth after 12 months of follow-up.

The earlier the diagnosis of MIH, ideally around the age of 8, when the first molars and permanent incisors are fully erupted, the better the prognosis for teeth affected by these developmental defects of the enamel (1,2,18). At this stage, it becomes feasible to implement preventive measures that contribute to the maintenance of the affected tooth using minimally invasive techniques. These measures include the use of fluoridated toothpaste, dietary counseling, scheduled and frequent follow-up visits to the dentist, the use of orthodontic bands to prevent tooth fracture, and direct composite resin restorations in the event of a carious cavity (9,15–17). In the case of the current patient, the diagnosis of MIH had been established early on, allowing preventive and therapeutic measures to be implemented, such as restorations and the application of an orthodontic band. However, it is worth noting that frequent maintenance appointments were not carried out, which is important for the long-term success of the treatment (25).

The color change in tooth enamel, a characteristic of MIH, may indicate differences in the hardness and porosity of the tissue, with yellow/brown stains being more porous and more susceptible to fractures than white stains (24,26). Although there have been studies showing that yellow/brown changes are more fragile than other color changes, the level of scientific evidence about this association is low, and there is an opportunity to develop scientific studies to validate the need for follow-up visits at shorter intervals (24,27). As for the type of treatment, the color change and factors such as the patient's age, socioeconomic conditions, the severity of the lesion and symptoms, the patient's expectations, and the number of teeth affected play a crucial role (9,14,28). These multiple factors must be carefully considered when formulating the treatment plan, highlighting the complexity of the clinical approach for patients with MIH.

While the treatment of affected posterior teeth is more related to the prevention of hypersensitivity and progression of caries, anterior teeth are of greater psychosocial concern and affect the patient's smile, causing aesthetic dissatisfaction and reducing their quality of life (29,30). The patient reported that he had been bullied and, therefore, began to smile less and show his teeth less when he smiled due to the stain on the buccal surface of element upper right incisor. The patient reported his satisfaction with the composite resin restoration at the follow-up appointment 12 months after the procedure.

Hypersensitivity to thermal or mechanical stimuli, frequently reported by patients with MIH, can significantly impact their quality of life (31). This hypersensitivity may be associated with hypomineralized enamel, which, although apparently intact, does not prevent bacterial penetration, allowing microorganisms to reach the dentinal tubules and consequently cause subclinical chronic pulp inflammation (32,33). Clinically, during dental care, the anesthetic procedure can become challenging due to this inflammation (34). Another significant impact that can occur in patients with MIH associated with hypersensitivity is the difficulty in performing oral hygiene properly, further increasing susceptibility to the development of caries lesions (8). Even with several teeth affected to varying degrees, the patient reported altered sensitivity only on upper left molar and no difficulty with hygiene, which was clinically proven.

In anterior teeth, minimally invasive techniques for removing the superficial layer of enamel with color alteration, such as microabrasion, can be indicated (9,14,35). This approach effectively uses light and superficial stains, providing successful results (9,14,16,35). Microabrasion can be combined with tooth whitening for moderately or severely affected teeth (16,35). The extent of the stain can be assessed using a light-curing device on the palatal side of the affected tooth, as shown in Figure 2-A. When the light is activated, an internal shadow can be seen on the tooth, and the darker the shadow, the deeper the stain (9). In these cases, microabrasion is ineffective, so this procedure was not included in the treatment plan for the patient, who had deep stains, even affecting the palatal side of upper right incisor (Figure 2-B). For this reason, a direct restoration in composite resin was proposed.

Within the minimally invasive techniques for treating anterior and posterior teeth with different degrees of severity of MIH lesions, another option is resin infiltration with high-fluidity resins, such as Icon (DMG, Hamburg, Germany) (17,36,37). The infiltration of the material allows it to fill the pores and large intercrystalline spaces in the enamel, modifying its optical properties and thus making the stains less visible (38). In addition to this advantage, there is the possibility of mechanically strengthening the enamel structure (17). However, it is important to highlight the challenges associated with this approach. The cost of the material is identified as a significant

limitation to its widespread use. Moreover, in cases of deep stains, as seen in Figure 2-B, where the stain reaches the palatal side of the affected tooth, the technique may not be indicated, as it may not fill the entire hypomineralized region (39).

Teeth with MIH, whether or not associated with caries lesions, can be directly restored using composite resins, glass ionomer cement (GIC), and resin-modified glass ionomer cement (RMIC) (23). GIC and RMIC have been indicated for provisional approaches, especially in cases involving treatment in uncooperative children (40). However, GIC restorations associated with selective removal of decayed tissue have demonstrated an effective approach after 24 months of follow-up (41). RMIC also proved effective after seven years of follow-up in molar restorations (42). The RMIC is superior in the analysis of annual failure compared to the GIC (23).

Due to the changes in the morphological characteristics of enamel affected by MIH, the presence of porosities and voids in the microstructure can result in adhesive failures and fractures, with enamel adhered to the resin fragment, characterizing a cohesive failure of the enamel (19). Because of these conditions, composite resin restorations in this structure become more susceptible to staining, wear, marginal fractures, secondary caries lesions, and retention problems, thus requiring frequent maintenance (19). Due to the low stability of the different adhesive systems on the affected enamel, it has been recommended that the preparation be extended to the healthy tissue, ensuring proper adhesion and less bacterial invasion (9,14,19,22). This information is congruent with the case reported, as in the case of upper left molar on the distal face, where the enamel affected by MIH may have resulted in adhesive failure. The procedure was successful in the other restorations in which the affected enamel was removed from the cavity margins, keeping the edges of the composite resin restoration in contact with healthy enamel.

Adhesion does not negatively impact dentin below the affected enamel (19). The restorative protocols used are the same as for healthy dentin, as they ensure good retention and reduce hypersensitivity (19).

Indirect restorations with full or partial coverage, whether metal, resin, or ceramic, are the treatment of choice for posterior teeth with MIH that have fractured or teeth with severe impairment and great loss of structure, demonstrating good clinical success (14,23,28). Young patients with severe molar MIH can receive a metal band to prevent tooth loss, provide proximal and occlusal stability, and help control hypersensitivity (16). Ceramic restorations are indicated for patients with gingival maturity, and the CAD/CAM system greatly facilitates this process (14). Extensive restorative treatments on severely compromised teeth can result in higher costs and high lifetime financial costs for the patient (35). In the case of upper left molar, the choice of indirect restoration using the CAD/CAM system provided speed and an efficient restoration with good marginal adaptation and greater treatment stability.

Further studies are needed to clarify the etiology of MIH and to identify effective restorative procedures in which the affected enamel is not removed, thus preserving a greater amount of tooth structure. Although several treatments for teeth affected by MIH are described in the literature, it is important to note that longitudinal follow-up studies are scarce.

CONCLUSION

This clinical case demonstrated the importance of early diagnosis and knowledge of the different clinical approaches to treating MIH lesions. The evolution of the condition prompted the replacement of the restorations, reinforcing the importance of continuous monitoring. Conservative direct composite resin restorations with healthy enamel edges proved effective after 12 months of follow-up. Cavities, where the MIH lesion was not completely removed from the margin, had unsuccessful restorations and required reintervention. This case highlights the complexity of restorative management of teeth affected by MIH, requiring personalized and adaptable approaches to the particularities presented by the patient.

The authors declare no conflicts of interest.

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REFERENCES

1. Goel N, Jha S, Bhol S, Dash BP, Sarangal H, Namdev R. Molar Incisor Hypomineralization: Clinical Characteristics with Special Emphasis on Etiological Criteria. J Pharm Bioallied Sci. 2021 Jun;13(Suppl 1):S651-S655.
2. Weerheijm KL, Jälevik B, Alaluusua S. Molar-incisor hypomineralisation. Caries Res. 2001 Sep-Oct;35(5):390-1.
3. Somani C, Taylor GD, Garot E, Rouas P, Lygidakis NA, Wong FSL. An update of treatment modalities in children and adolescents with teeth affected by molar incisor hypo-

mineralisation (MIH): a systematic review. Eur Arch Paediatr Dent. 2022;23(1):39-64.
4. Lopes LB, Machado V, Mascarenhas P, Mendes JJ, Botelho J. The prevalence of molar-incisor hypomineralization: a systematic review and meta-analysis. Sci Rep. 2021 Nov 17;11(1):22405. doi: 10.1038/s41598-021-01541-7. PMID: 34789780. PMCID: PMC8599453.
5. Americano GCA, Jacobsen PE, Soviero VM, Haubek D. A systematic review on the association between molar incisor hypomineralization and dental caries. Int J Paediatr Dent. 2017 Jan;27(1):11-21.
6. Duarte MBS, Carvalho VR, Hilgert LA, Ribeiro APD, Leal SC, Takeshita EM. Is there an association between dental caries, fluorosis, and molar-incisor hypomineralization?. J Appl Oral Sci. 2021;29:e20200890.
7. Linner T, Khazaei Y, Bücher K, Pfisterer J, Hickel R, Kühnisch J. Hypersensitivity in teeth affected by molar-incisor hypomineralization (MIH). Sci Rep. 2021 Sep 9;11(1):17922.
8. Ebel M, Bekes K, Klode C, Hirsch C. The severity and degree of hypomineralisation in teeth and its influence on oral hygiene and caries prevalence in children. Int J Paediatr Dent. 2018 Nov;28(6):648-57.
9. Sundfeld D, da Silva L, Kluppel OJ, Santin GC, de Oliveira R, Pacheco RR, *et al*. Molar Incisor Hypomineralization: Etiology, Clinical Aspects, and a Restorative Treatment Case Report. Oper Dent. 2020 Jul 1;45(4):343-51.
10. Alhowaish L, Baidas L, Aldhubaiban M, Bello LL, Al-Hammad N. Etiology of Molar-Incisor Hypomineralization (MIH): A Cross-Sectional Study of Saudi Children. Children (Basel). 2021;8(6):466.
11. Teixeira TP de S, Pereira PSA, Carvalho F de AR, Soviero VM. Influence of genetics on the occurrence of enamel hypomineralization affecting permanent and primary teeth: A scoping review. Int J Paediatr Dent. 2023 Oct 23.
12. Lygidakis NA, Garot E, Somani C, Taylor GD, Rouas P, Wong FSL. Best clinical practice guidance for clinicians dealing with children presenting with molar-incisor-hypomineralisation (MIH): an updated European Academy of Paediatric Dentistry policy document. Eur Arch Paediatr Dent. 2022 Feb;23(1):3-21.
13. Bussaneli DG, Vieira AR, Santos-Pinto L, Restrepo M. Molar-incisor hypomineralisation: an updated view for aetiology 20 years later. Eur Arch Paediatr Dent. 2022 Feb;23(1):193-8.
14. Alzahrani AY, Alamoudi NMH, El Meligy OAES. Contemporary Understanding of the Etiology and Management of Molar Incisor Hypomineralization: A Literature Review. Dent J (Basel). 2023 Jun 23;11(7):157.
15. Amaechi BT, Farah R, Liu JA, Phillips TS, Perozo BI, Kataoka Y, *et al*. Remineralization of molar incisor hypomineralization (MIH) with a hydroxyapatite toothpaste: an in-situ study. BDJ Open. 2022 Dec 10;8(1):33.
16. da Cunha Coelho ASE, Mata PCM, Lino CA, Macho VMP, Areias CMFGP, Norton APMAP, *et al*. Dental hypomineralization treatment: A systematic review. J Esthet Restor Dent. 2019 Jan;31(1):26-39.
17. Nogueira VKC, Mendes Soares IP, Fragelli CMB, Boldieri T, Manton DJ, Bussaneli DG, *et al*. Structural integrity of MIH-affected teeth after treatment with fluoride varnish or resin infiltration: An 18-Month randomized clinical trial. J Dent. 2021 Feb;105:103570.
18. Neves AB, Soares DV, Soviero VM. Hipomineralização de molares e incisivos: uma revisão de literatura. Rev Nav Odontol. 2016;43(1):38-42.
19. Krämer N, Bui Khac NN, Lücker S, Stachniss V, Frankenberger R. Bonding strategies for MIH-affected enamel and dentin. Dent Mater. 2018 Feb;34(2):331-40.
20. Elhennawy K, Manton DJ, Crombie F, Zaslansky P, Radlanski RJ, Jost-Brinkmann PG, *et al*. Structural, mechanical and chemical evaluation of molar-incisor hypomineralization-affected enamel: A systematic review. Arch Oral Biol. 2017 Nov;83:272-81.
21. Bozal CB, Kaplan A, Ortolani A, Cortese SG, Biondi AM. Ultrastructure of the surface of dental enamel with molar incisor hypomineralization (MIH) with and without acid etching. Acta Odontol Latinoam. 2015;28(2):192-8.
22. Lagarde M, Vennat E, Attal JP, Dursun E. Strategies to optimize bonding of adhesive materials to molar-incisor hypomineralization-affected enamel: A systematic review. Int J Paediatr Dent. 2020 Jul;30(4):405-20. doi: 10.1111/ipd.12621. Epub 2020 Feb 12. PMID: 31990108.
23. Weber KR, Wierichs RJ, Meyer-Lueckel H, Flury S. Restoration of teeth affected by molar-incisor hypomineralisation: a systematic review. Swiss Dent J. 2021 Dec 6;131(12):988-97.
24. Jorge RC, Dos Papoula GorniReis P, Marañón-Vásquez GA, Masterson D, Cople Maia L, Mendes Soviero V. Are yellow-brownish opacities in hypomineralized teeth more prone to breakage than white-creamy ones? A systematic review. Clin Oral Investig. 2022 Sep;26(9):5795-808.
25. Sekundo C, Jung M, Muscholl C, Frese C. Oral health-related quality of life and survival analysis after preventive and restorative treatment of molar-incisor hypomineralisation. Sci Rep. 2024 Jan 8;14(1):777.
26. Ritto FP, Tiwana KR, Schmitz TA, Dacus ZL, Borges MAP, Canellas JV. A qualitative analysis of treatment patterns for mild and severe molar hypomineralization in permanent teeth: A systematic review. Pediatr Dent 2023;45(4):281-91.
27. Cabral RN, Nyvad B, Soviero VLVM, Freitas E, Leal SC. Reliability and validity of a new classification of MIH based on severity. Clin Oral Investig. 2020 Feb;24(2):727-34.
28. Rodd HD, Graham A, Tajmehr N, Timms L, Hasmun N. Molar Incisor Hypomineralisation: Current Knowledge and Practice. Int Dent J. 2021 Aug;71(4):285-91. doi: 10.1111/idj.12624. Epub 2021 Jan 27. PMID: 34286697. PMCID: PMC9275314.
29. Hasmun N, Vettore MV, Lawson JA, Elcock C, Zaitoun H, Rodd HD. Determinants of children's oral health-related quality of life following aesthetic treatment of enamel opacities. J Dent. 2020 Jul;98:103372.
30. Jawdekar AM, Kamath S, Kale S, Mistry L. Assessment of oral health-related quality of life (OHRQoL) in children with molar incisor hypomineralization (MIH) - A systematic review and meta-analysis of observational studies. J Indian Soc Pedod Prev Dent. 2022 Oct-Dec;40(4):368-76.

31. Kisacik S, Ozler CO, Olmez S. Molar incisor hypomineralization and oral health-related quality of life: a sample of 8-12-years-old children. Clin Oral Investig. 2024 Jan 20;28(1):105.
32. Fagrell TG, Lingström P, Olsson S, Steiniger F, Norén JG. Bacterial invasion of dentinal tubules beneath apparently intact but hypomineralized enamel in molar teeth with molar incisor hypomineralization. Int J Paediatr Dent. 2008 Sep;18(5):333-40.
33. Dixit UB, Joshi AV. Efficacy of Intraosseous Local Anesthesia for Restorative Procedures in Molar Incisor Hypomineralization-Affected Teeth in Children. Contemp Clin Dent. 2018 Sep;9(Suppl 2):S272-7.
34. Özgül BM, Sakaryalı D, Tirali RE, Çehreli SB. Does MIH Affects Preoperative and Intraoperative Hypersensitivity?. J Clin Pediatr Dent. 2022 May 1;46(3):204-10.
35. Costa JLSG, Nogueira BR, de Oliveira Junior OB, Pretel H. Association of microabrasion and tooth whitening with LED/laser system in the treatment of incisor hypomineralization: 3-year follow-up. Photodiagnosis Photodyn Ther. 2021 Mar;33:102197. doi: 10.1016/j.pdpdt.2021.102197. Epub 2021 Jan 27. PMID: 33515762.
36. Mazur M, Westland S, Guerra F, Corridore D, Vichi M, Maruotti A, *et al*. Objective and subjective aesthetic performance of icon® treatment for enamel hypomineralization lesions in young adolescents: A retrospective single center study. J Dent. 2018 Jan;68:104-8.
37. Sara Mistry N, Muwaquet Rodriguez S. Comparison of aesthetic treatments for molar-incisor hypomineralisation: Systematic review and meta-analysis. Saudi Dent J. 2024 Feb;36(2):222-7.
38. Altan H, Yilmaz RE. Clinical evaluation of resin infiltration treatment masking effect on hypomineralised enamel surfaces. BMC Oral Health. 2023 Jul 3;23(1):444.
39. Brescia AV, Montesani L, Fusaroli D, Docimo R, Di Gennaro G. Management of Enamel Defects with Resin Infiltration Techniques: Two Years Follow Up Retrospective Study. Children (Basel). 2022 Sep 8;9(9):1365.
40. Fragelli CM, Souza JF, Jeremias F, Cordeiro Rde C, Santos-Pinto L. Molar incisor hypomineralization (MIH): conservative treatment management to restore affected teeth. Braz Oral Res. 2015;29:S1806-83242015000100271.
41. Durmus B, Sezer B, Tugcu N, Caliskan C, Bekiroglu N, Kargul B. Two-Year Survival of High-Viscosity Glass Ionomer in Children with Molar Incisor Hypomineralization. Med Princ Pract. 2021;30(1):73-9. doi: 10.1159/000508676. Epub 2020 May 15.
42. Pessôa CP, Pion L, Reyes A, Matos R, Alencar CF, Novaes TF, *et al*. Conservative approach for molar-incisor hypomineralization: a case report and 7-year follow-up. Gen Dent. 2018 May-Jun;66(3):e1-e4.

LITERATURE REVIEW

DENTAL BIOCORROSION: A LITERATURE REVIEW

BIOCORROSÃO DENTÁRIA: UMA REVISÃO DE LITERATURA

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ABSTRACT

Biocorrosion is the tooth demineralization caused by frequent exposure to intrinsic and/or extrinsic acids. The aim of this study was to review the literature on the prevalence, etiology, diagnosis, prevention, treatment and monitoring of biocorrosion. An advanced search was carried out in the databases PubMed, Biblioteca Virtual em Saúde (BVS) and Portal Periódicos CAPES using the health sciences descriptors DeCS and MeSH. Articles published in scientific journals in the last 10 years were included, in their full versions, in Portuguese, English and Spanish. Duplicate articles, books and theses were excluded. In the end, 5,474 articles were found and, after reading the titles and abstracts, 40 articles were selected for full reading. Biocorrosion of dental tissues is increasingly common in the general population; currently, around 29% of adults show signs of the disease. For this reason, it should be diagnosed as early as possible to avoid serious damage to the tooth structure. Thus, dental surgeons should be aware of oral exposure to gastric acids and eating habits with frequent consumption of acidic foods or drinks, which are the main etiological agents of this condition, while recognizing the associated clinical signs. Prevention is important at all stages, and treatment varies among direct restorations, indirect restorations or full crowns. In addition, patient counseling and monitoring of this condition are fundamental. Therefore, preventive measures are indispensable to avoid or halt the progression of the disease. Treatment should prioritize minimally invasive approaches, and it is crucial to monitor them to ensure good control of this condition.

Keywords: Dental etching; Tooth erosion; Tooth wear; Oral health; Feeding behavior; Demineralization.

RESUMO

A Biocorrosão é a desmineralização do dente causada pela exposição frequente a ácidos intrínsecos e/ou extrínsecos. O objetivo deste trabalho foi realizar uma revisão de literatura sobre prevalência, etiologia, diagnóstico, prevenção, tratamento e acompanhamento da biocorrosão. Realizou-se uma pesquisa avançada nas bases de dados PubMed, Biblioteca Virtual em Saúde (BVS) e Portal Periódicos CAPES com os descritores em ciências da saúde DeCS e MeSH. Foram incluídos artigos publicados em revistas científicas nos últimos 10 anos, em suas versões completas, em português, inglês e espanhol. Artigos duplicados, livros e teses foram excluídos. Ao final, 5.474 artigos foram encontrados e, após a leitura dos títulos e resumos, 40 artigos foram selecionados para a leitura completa. A biocorrosão dos tecidos dentários está cada vez mais comum na população em geral; atualmente, cerca de 29% dos adultos apresentam sinais da doença. Por isso, seu diagnóstico deve ser feito o mais precocemente possível, evitando danos graves à estrutura dentária. Para isso, os cirurgiões-dentistas devem estar atentos à exposição bucal a ácidos gástricos e a hábitos alimentares com consumo frequente de alimentos ou bebidas ácidas, os quais são os principais agentes etiológicos dessa condição, enquanto reconhecem os sinais clínicos associados. A prevenção é importante em todos os estágios, e o tratamento varia entre restaurações diretas, indiretas ou coroas totais. Além disso, a orientação do paciente e o acompanhamento dessa condição são fundamentais. Conclui-se que medidas preventivas são indispensáveis para evitar ou paralisar a progressão da doença e o tratamento deve priorizar abordagens minimamente invasivas, sendo crucial acompanhá-las para garantir um bom controle dessa condição.

Palavras-chave: Corrosão dentária; Erosão dentária; Desgaste dentário; Saúde bucal; Hábitos alimentares; Desmineralização.

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INTRODUCTION

Tooth wear is physiological and occurs over time, but when the destruction is excessive enough to compromise function, aesthetics and quality of life, it is considered pathological (1-4). Approximately 2 to 4% of the adult population has a small amount of severe wear; however, this percentage increases to 10% in old age (5).

Conceptually, erosion is a physical mechanism, while the term corrosion is more appropriate for describing chemical, biochemical and electrochemical phenomena. The term corrosion differs from biocorrosion by the presence of the prefix "bio", which in this case refers to dental tissues (6 - 8).

Biocorrosion is defined as the chemical loss of mineralized tooth substance caused by exposure to acids not derived from oral bacteria (9). The prevalence of this condition has increased recently, especially in the young population (10).

Teeth are routinely exposed to acids of exogenous and endogenous origin from the diet and gastric disorders, respectively. To be considered a risk, exposure must be continuous, i.e. over several days and for a prolonged time in the mouth, which is considered a serious condition (2). Gastroesophageal reflux disease (GERD) is often responsible for high levels of intraoral exposure to endogenous acids (11). Acids from food are considered an exogenous factor, as are medications and the work environment (11,12).

Prevention of biocorrosion is very important (5), as is early diagnosis in order to avoid excessive tooth wear. Therefore, the dental surgeon must be aware about the patient's health conditions and diet, in addition to the clinical aspect of biocorrosion (13). In certain cases, restorative treatment may be necessary since it reduces thermal sensitivity, prevents pulp involvement, increases tooth strength, restores tooth shape, function and aesthetics (14).

Although the incidence of this condition is high, it is still underestimated (10), prompting the need for a better understanding of its clinical characteristics. Therefore, the aim of this study was to disseminate information on the etiology, prevalence, diagnosis, prevention, treatment and monitoring of dental biocorrosion through a narrative literature review, based on current scientific literature.

LITERATURE REVIEW

Methodology

The study was based on an integrative literature review using an advanced search in the PubMed, Virtual Health Library (VHL) and CAPES Periodicals Portal databases with the Health Sciences Descriptors (DeCS): "Tooth Erosion", "Tooth Wear", "Endogenous Acids" and "Acid Feed", both in MeSH (Medical Subject Headings) and TIAB (title and abstract), and with the Boolean operators AND and OR. The initial search resulted in 5,474 articles and, after applying the inclusion and exclusion criteria (Table 1), 40 papers were selected to this literature review, as shown in the flowchart below (Figure 1).

TABLE 1. INCLUSION AND EXCLUSION CRITERIA FOR THE ARTICLES

INCLUSION	EXCLUSION
Articles in full and free versions or available on the CAPES platform;	Duplicate articles;
Published between 2013 and 2023;	Books and theses;
Languages: Portuguese, English and Spanish;	
Articles related to the topic.	
No restrictions on the type of study;	

Biocorrosion

Tooth enamel is able to resist to aggression of the oral environment throughout life (7). However, when associated with acids, the loss of mineral structure is notorious and of great clinical concern (12,15).

Thus, biocorrosion is a complex process caused by the activity of acids of different origins, which, when they come into contact with teeth, promote chemical reactions and a biochemical degradation process takes place (8). These reactions involve the demineralization of enamel by dissolving calcium and phosphate (8).

Frequent, intense, and prolonged exposure to acids results in softening of the tooth surface (16,2), which begins with microscopic loss of structure until it develops into a clinically visible lesion (8). Besides, acid-weakened cheeks become more vulnerable to

abrasive forces, leading to severe mineral loss during oral hygiene (16).

The severity of biocorrosion is mostly restricted to enamel, but without proper control and treatment it can reach dentin and the patient may experience hypersensitivity (14). Once the dentin is exposed, its loss progresses faster than that of the enamel, with "excavations" appearing on the occlusal surface of the teeth (13).

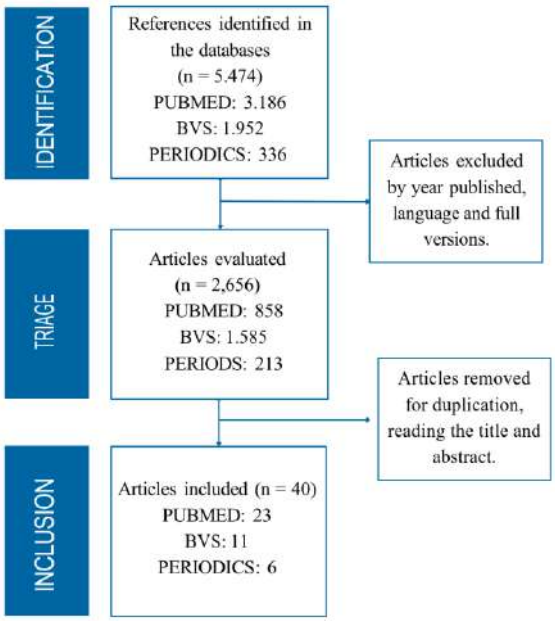


Figure 1. *Flowchart of study inclusion.*

Prevalence

Biocorrosion is a multifactorial and irreversible condition of growing concern to researchers and dentists (15,16). Older age groups are the most affected, due to the longer period of use and dental exposure (5).

However, studies show that primary teeth are more susceptible to biocorrosion than permanent teeth, due to their lower mineralization and structural morphology (17,18). It should not be considered a short-term physiological process, but rather a predictive indicator of wear in the permanent dentition (15).

Worldwide, around 30 to 50% of deciduous teeth are affected by this condition, while permanent teeth have an estimated prevalence of 20 to 45% (19). In Brazil, adolescents show a prevalence of 13 to 34% (19).

Etiology

GERD affects approximately 10% of the Brazilian population (9) and is often diagnosed through oral manifestations (13). Eating disorders, such as anorexia, bulimia and rumination, also contribute as an intrinsic etiology (2,15), exposing teeth to endogenous acids on a regular basis (11).

The chemical degradation of mineral tissue is related to the length of time, the duration interval and the frequency of acid attacks, which are directly proportional to the level of wear (20).

Dietary acid is the predominant extrinsic cause. A case-control study suggests that regular consumption of two acids a day could result in tooth wear. An apparently healthy diet, such as fruit juice in the morning, lunch with salad dressing, an apple in the afternoon and a glass of wine in the evening, represents consecutive acidic challenges during the day (11).

The risk of biocorrosion increases with the amount and frequency of ingestion of acidic products and their composition determines their corrosive potential (8). pH values below 5.5 are critical for dental corrosion (8). Moreover, the buffering capacity, adhesion, chelating effect and phosphate and fluoride content of the food must also be taken into account (21).

The calcium present in the formulations is the main protective factor, inhibiting enamel demineralization when present in salivary fluids, causing a reduction in the rate of tooth softening (15,2,22). One study indicated that the consumption of milk and yogurt is linked to a lower prevalence of biocorrosion, precisely for this reason (2).

Vinegars, vegetables and fruits rich in acids such as citric, tartaric, phosphoric and lactic increase the risk of biocorrosion (8). A clinical study revealed greater biocorrosion wear in vegetarians due to frequent consumption of acidic foods such as vinegar (23). In this experiment, the enamel wear caused by vinegar-based sauces (9.4 to 14.2 µm) was statistically higher than the average wear induced by orange juice (2.4 µm) (23).

Lifestyle changes have recently increased the consumption of acidic drinks (10), such as isotonic drinks, wines and citrus fruit juice (15). Drinking habits are a determining factor, with a lower risk of biocorrosion when drinking quickly rather than several sips during the day, as well as using a straw positioned towards the palate rather than in front of the teeth (2). Temperature also matters: high temperatures accelerate the chemical reaction, dissolving the enamel more quickly (22).

People drink various liquids with biocorrosive potential throughout the day. Pure mineral water is not harmful, but when added to lemon and citric acid, the pH drops to 3.2 and the enamel is easily demineralized (22). Other everyday drinks, such as soft drinks and fruit juices, have a critical pH and cause enamel and dentin structure loss. Figure 2 (21) shows that Coke and lemon juice have a high biocorrosive potential due to their low pH. Alcoholic beverages also have this potential, when pure and with a pH between 4.1 and 4.4, causing no change in the enamel's surface hardness, but when citric acid is added, they become biocorrosive (22).

ACID POTENTIAL OF DRINKS			
Drink	**Initial pH**	**Enamel**	**Dentin**
Coke	2.47	7.5	6.6
Diet Coke	2.59	5.2	3.5
Sprite	2.68	26.1	17.7
Apple juice	3.38	27.1	15.2
Orange juice	3.87	24.3	20.2
Lemon juice	2.50	32.0	28.3
Red Bull	3.38	16.6	17.0

Figure 2. *Initial pH of the drinks and average mass loss (mg) of enamel and dentin after seven days of exposure to acidic liquids. Source: Adapted from Zimmer S et al., 2015 (21).*

The rehydration and electrolyte replacement properties of carbonated and isotonic drinks lead to their widespread consumption by athletes during intense aerobic physical activity (15). However, the pH of these drinks can be as low as 2.9 (22). However, these drinks are increasingly being used by children and young adults due to their popularity (15,19).

Most of them have a critical pH for the oral environment and contain high concentrations of fermentable carbohydrates, promoting demineralization (15). In addition, the product's biocorrosive potential increases during and after exercise due to reduced salivary secretion. Therefore, athletes are often exposed to these risk factors, and their oral health is linked to sports performance (15).

Certain medicines and supplements have biocorrosive potential if they are in the formula of chewable tablets or effervescent drinks. Examples include acid saliva stimulants, products containing acetylsalicylic acid, vitamin C tablets and drugs that have the side effect of reducing salivary flow (2).

Included in the extrinsic factors is occupational exposure to acidic environments (15). The mist and acidic solutions present in battery factories and electroplating companies can cause varying degrees of tooth loss (24). One study reported that 31% of workers suffered from biocorrosion when exposed to sulphuric acid mist (24). Also, professional wine tasters present a hidden risk due to the high acid content of this drink, identifying a direct correlation between years of tasting and the rate of biocorrosion (25).

As a result, teeth become vulnerable and structural loss can be exacerbated by certain behaviors, such as bruxism, which causes wear by grinding teeth (1,3). Cigarette smoking can also be considered a modulator of biocorrosion, as heating by smoke can lead to changes in the morphology of hydroxyapatite crystals and greater mineral loss (26).

Saliva

Saliva is the most important natural agent against this issue (27), as it is able to prevent acid demineralization and promote remineralization of the tooth surface (27,19). By balancing calcium and phosphate concentrations, saliva keeps the oral pH close to physiological (19,1) and neutralizes and dilutes acids that cause biocorrosion (8,13,28). Furthermore, calcium and saliva proteins form a film that preserves the integrity and mineral homeostasis of the tooth (8,27).

The frequency of acid exposure reduces salivary pH, prolonging the critical period and decreasing its buffering capacity. In contrast, high-risk patients with no signs of tooth decay probably have enhanced salivary protective properties, with a greater amount of collagen phosphoproteins and increased salivary flow, resulting in a thicker salivary film (8).

Salivary flow is influenced by various factors, such as radiotherapy in the head and neck region, medication (benzodiazepines, antihistamines and medication for Parkinson's disease), intense physical activity and systemic conditions such as Sjogren's Syndrome (2,22). Such conditions can lead to a reduction in salivary flow, and the use of artificial saliva formulations is indicated to treat the symptoms of dry mouth (27). Salivary tests can also be recommended to identify patients at greater risk of biocorrosion, making it possible to prevent more severe damage to the tooth structure (8).

Wear Index

The Basic Erosive Wear Examination (BEWE) is the index commonly used in epidemiological research to quantify the level of wear. It's a practical screening method that allows identification and documentation to be carried out quickly and cost-effectively (11). Its criteria range from 0 to 3 depending on the tooth surface, in which each sextant is scored based on its most affected surface and the sum of all the scores results in the score, which ranges from 0 to 18. The cumulative BEWE score of all the sextants will determine the level of risk between low, medium or high. Clinical management is indicated for each level (29), as shown in the following diagram (Figure 3).

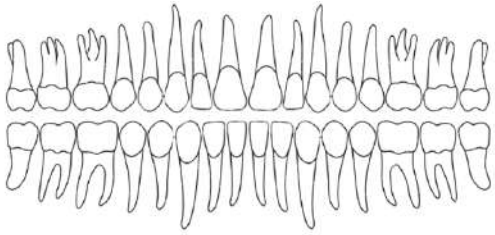
Diagnosis

Considering that the condition is multifactorial, patient assessment should be comprehensive following a diagnostic protocol that includes medical history, dietary description, explanation of work environment, oral hygiene habits, dental report, extraoral and intraoral clinical examination, as well as complementary salivary (13).

The first clinical signs of change are difficult to diagnose clinically, as they are subtle alterations involving superficial loss of the acid-etched surfaces and can be easily confused with the tooth's natural appearance (5). But as it progresses, biocorrosion can be visualized more easily (5).

Incipient lesions located on the occlusal surface of posterior teeth show loss of enamel shine, flattening

BEWE SCORES
0 - No tooth wear due to erosion
1 - Initial loss of surface texture
2 - Loss of hard tissue on < 50% of the surface area
3 - Loss of hard tissue on > 50% of the surface area



highest score in 1st sextant + highest score in 2nd + 3rd + 4th + 5th + 6th

Sum of the scores of the 6 sextants (min 0 and max 18)

CLINICAL MANAGEMENT GUIDE BASED ON THE RISK OF EROSION		
Risk	**Sum of the scores**	**Clinical Management**
None	≤ 2	Routine maintenance + Check-up every 3 years
Low	3- 8	Assessment and advice on eating habits/oral hygiene + Routine maintenance and observation + Consultation every 2 years
Medium	9- 13	Assessment of eating habits and oral hygiene + Identification of etiological factors + Developing strategies to eliminate impacts + Consider using fluoride or another strategy + Avoid restorations + Monitor with plaster models, photographs or silicone molds + Consultation at 6-12 month intervals
High	14 or more	Assessment of eating habits and oral hygiene + Identification of etiological factors + Develop strategies to eliminate impacts + Consider using fluoride or another strategy + Avoid restorations + Monitor with plaster models, photographs or silicone molds + In cases of severe progression, consider the need for restorations + Consultation at 6-12 month intervals

Figure 3. *Diagram of the BEWE scores, their sum and the clinical management guide. Source: Adapted from Aránguiz et al., 2020 (29).*

of scars and fissures, rounded and polished surfaces and even exposure of dentin (Figure 4) (13,18,30).

In anterior teeth, incipient lesions are characterized by the presence of more translucent incisal edges (Figure 5), while the enamel in the cervical region is intact due to the accumulation of biofilm in this region, which becomes a barrier to the action of acids (13,18).

Figure 4. *Initial level of biocorrosion in posterior teeth. On the occlusal face, loss of enamel shine, flattening of scars and fissures, rounded and polished surfaces and dentin exposure can be observed.*

Figure 5. *Initial level of biocorrosion in anterior teeth. On the buccal side, there is greater translucency on the incisal edges and intact tooth enamel in the cervical region.*

In Europe, the prevalence of moderate levels of wear is approximately 29%, while for severe levels is 3% (1,5). In moderate cases, saucer-shaped lesions, dentin concavities, rounded edges and dentin exposure can be seen on the occlusal surface of the posterior teeth (Figure 6) (18,13,2,31).

Figure 6. *The lower first molar is at an intermediate level of biocorrosion, with a saucer-shaped lesion, concavities in the dentin, rounded edges and dentin exposure.*

In more severe cases, the disappearance of occlusal morphology can be seen (Figure 7), with great loss of enamel and dentin, great exposure of dentin, rounded edges and even pulp exposure (18,13).

Figure 7. *Advanced level of biocorrosion in posterior teeth. There is a marked loss of enamel and dentin on the occlusal and palatal faces, pronounced dentin exposure and rounded edges.*

Biocorrosion alters the physical properties of enamel, which can affect its interface with the restoration (31,32). In this context, the amalgam can be seen to be quite polished and appear to be above the tooth surface (13). This is due to the loss of minerals, making the organic content more evident and causing damage to the durability of restorations (31).

Wear due to gastric disorders is frequent on the palate, with 41.6% of lesions located in this area (20); the occlusal surface of the lower molars is also affected (13). Extrinsic biocorrosion, on the other hand, occurs mainly on the buccal surfaces of the upper front teeth and on the buccal and occlusal surfaces of the posterior teeth (13).

Biocorrosion can be classified according to pathogenic activity into two types: the active lesion is the one in progress, characterized by the thin thickness of the enamel walls with a honeycomb appearance, and presents clinically as a dull, opaque enamel surface. The inactive, latent or paralyzed lesion, on the other hand, has a thinner enamel thickness and is clinically shiny (33).

Prevention

Regarding biocorrosive challenges, if the condition is not early solved, controlling tooth wear will be even more complex (31). Based on an analysis of the patient's profile and conditions, an individualized preventive program should be suggested by the dentist (2). Although it focuses more on early lesions, prevention is indicated at all stages because, regardless of severity, preventive counseling can slow down progression. Most preventive actions involve toothpaste, mouthwash and dietary changes (5).

The daily use of toothpaste is the main source of active substances in teeth, especially fluorides and stannous compounds (15). Fluoride has a well-recognized ability to increase remineralization and prevent demineralization (4). Stannous fluoride, on the other hand, improves both the quality and quantity of the film acquired on the enamel, providing protection against chemical aggression. However, it is important to note that toothpastes contain abrasive agents that

can neutralize the beneficial effect of these active substances (17).

Rinses with stannous fluoride have a protective effect, increasing the quantity and quality of the acquired film (4). However, they can cause stains on the teeth and tongue, so it is advisable to follow the instructions for use and guidance provided by the dentist (4).

Acid from food is the main controllable factor in the biocorrosion process. Although challenging, altering daily eating habits can lead to a reduction in tooth wear, consequently promoting greater tooth longevity (5). Minimizing the frequent intake of potentially harmful foods and drinks is extremely important in this context.

Interestingly, fluoride varnishes showed to be a good option to prevent biocorrosion. An in vitro study revealed that its application can prevent surface loss for up to 70 minutes in biocorrosive challenges, when not associated with abrasion (4). The protective effects of laser application on the demineralized surface have also been observed, as it promotes a smoother surface (13). Besides, the effectiveness of ionized alkaline water (pH between 9 and 10) in preventing dental biocorrosion caused by acidic drinks has been investigated and proven (34).

The success of such prophylactic strategies is difficult to achieve, though, since most of them depend on patient compliance (28).

Treatment

To choose a treatment, the dentist must consider the structural integrity of the teeth, hypersensitivity, the amount of structure lost, whether there is a loss of Vertical Occlusion Dimension (VOD), loss of function and the patient's aesthetic complaint (13).

Direct procedures have often been recommended, especially for young patients (35, 31), as they are conservative and economical (36). Composite resin-based materials can relieve hypersensitivity, increase resistance to acid attacks, reinforce the surface of teeth, as well as other advantages such as the fact that they vary in shade and are more resistant than glass ionomer-based materials (31). However, the main difficulty encountered in this approach lies in the preservation of composite resin restorations (5). This is due to the understanding that biocorrosion progressively compromises the quality of adhesion over time (14).

In the intermediate stages, treatment may involve direct and indirect dental restorations (10). In certain cases, ceramic veneers can be a good option when coupled with minimal intervention. Its use is becoming increasingly popular due to improvements in fracture resistance and better adhesive cementation (37). CAD-CAM anterior veneers and ultra-thin occlusal laminates have been proven to be effective over time, as shown by a case report that carried out a reassessment approximately 3 years after the initial procedure and revealed only a slight increase in roughness (38).

If biocorrosion reaches a severe stage, resulting in the loss of 50% or more of the dental crown, composites may not have longevity, especially in cases with an underlying component such as bruxism. In such circumstances, full ceramic crowns can be recommended due to their proven durability (5).

In deciduous teeth, the management of biocorrosion differs from the protocol used in permanent teeth. When there are no painful symptoms, the condition needs to be monitored. Small areas of sensitivity can be restored with composite resin. In more severe cases, steel crowns may be indicated (39).

Follow-up

Assessing the progress of biocorrosion or the treatment carried out is extremely important for longitudinal clinical monitoring (2). In this context, it is possible to determine preventive measures to be implemented and the need for new interventions (5).

Long-term clinical follow-up can be done via intraoral scanning, study models (Figure 8), standardized photographs or index classification (2,11). This will provide information on the rate of normal or pathological progression of biocorrosion, the severity of any underlying health condition of the individual, as well as protecting the dentist from litigation (11).

Figure 8. *Study model that makes it possible to visualize biocorrosion on copied teeth.*

DISCUSSION

Biocorrosion is highly prevalent in the population, and the dentist must be able to identify it promptly and monitor this condition effectively (9). The trend is for the prevalence to increase even further due to the new generation's dietary changes, where the consumption of acidic foods is routine (31).

Early diagnosis is essential to prevent serious and irreversible damage (13), but it is known that it is neglected due to the difficulty in carrying it out (40). Thereby, the dentist must be aware of the causes, risk factors and clinical manifestations of this condition, in order to indicate effective and individualized preventive habits, as well as determining the best treatment according to each case (13,18).

A study evaluating the quality of referrals to secondary care services revealed that most dentists do not attempt to quantify the degree of wear (40). This underscores the need to expand knowledge about biocorrosion quantification indices, such as the BEWE index, which is a fundamental tool for recording and monitoring this condition (5).

To effectively integrate the diagnosis of biocorrosion into clinical practice, a detailed anamnesis is essential, addressing crucial points. These include the patient's profession and/or work environment, their history of physical exercise (frequency and consumption of energy drinks), smoking or the presence of bruxism, medical history of systemic diseases and/or gastric disorders, as well as keeping a detailed food diary for approximately four days (13).

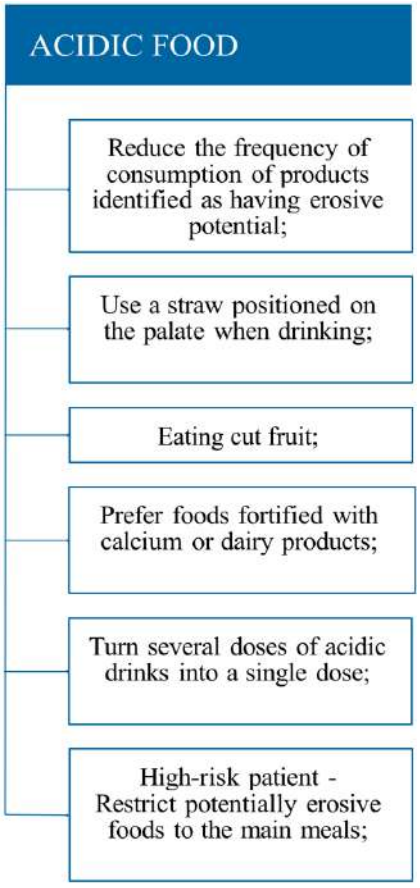


Figura 9. *Guidance for patients with an acid food diary. Source: Adapted from Dundar A et al., 2014 (13).*

Linked to this is the extraoral clinical examination and the intraoral clinical examination. In the latter, each dental surface is observed in a clean, dry and well-lit environment (18). In certain cases, complementary tests, such as salivary function and flow, may be valid (11).

According to one study, adults with a higher level of knowledge about biocorrosion tend to consume fewer acidic drinks per day, indicating that a lack of knowledge is an obstacle to controlling and preventing biocorrosion (30). It is a role for the dentist to educate patients about this condition, in order to prevent the progression of wear and the occurrence of serious cases (Figure 9).

Controlling the etiological factors is fundamental to successful treatment (19), but changing the diet is a challenge. Although foods with a high biocorrosive potential, such as orange juice, are harmful, it is important to emphasize that certain nutrients are valuable for health and should not be eliminated from the diet (21).

With regard to GERD, if the demineralization of tooth structure is diagnosed early enough, before the damage is irreversible, the enamel can be remineralized through preventive behavioral and dietary modifications, as well as the use of medications mentioned in the image below (13).

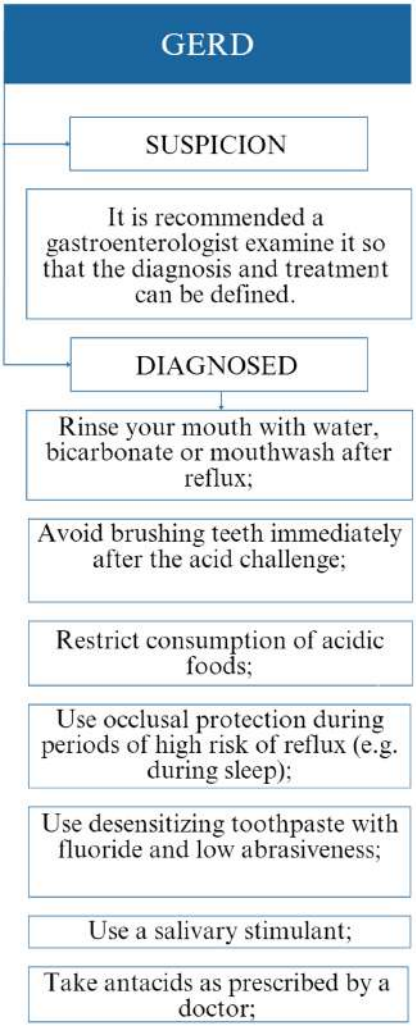


Figura 10. *Orientações aos pacientes com DRGE. Fonte: Adaptado de Lourenço et al., (13).*

Biocorrosion is an irreversible process that can compromise the dentition for life, thus requiring dental interventions (18). There are different treatment options, but it is known that the dental surgeon´s approach

should prioritize minimally invasive intervention (36), as well as seeking strategies for the potential use of materials, assessing the cost-benefit for the patient and examining the long-term performance of such an approach (31).

The limitations of this study include the need for further studies into emerging risk factors associated with new dietary trends that contribute to increased biocorrosion. Likewise, it is important to develop and evaluate new diagnostic techniques capable of identifying this condition in the early stages.

CONCLUSION

Biocorrosion is a condition commonly found in the world's population, which continues to grow steadily. It is crucial to understand it to promote both the patient's oral and general health, as it is closely linked to their well-being. To diagnose it, it is essential to take a detailed medical history, identifying the factors that cause it and recognizing its clinical characteristics. In addition, preventive measures are essential to avoid or halt its progression. Treatment should prioritize minimally invasive approaches that are effective, and it is crucial to monitor them to ensure good control of this condition.

The authors declare no conflict of interest.

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REFERENCES

1. Madariaga VI, Pereira-Cenci T, Walboomers XF, Loomans BAC. Association between salivary characteristics and tooth wear: A systematic review and meta-analysis. J Dent. 2023 Nov 1;138:104692-2.
2. Carvalho TS, Colon P, Ganss C, Huysmans MC, Lussi A, Schlueter N, *et al*. Consensus report of the European Federation of Conservative Dentistry: erosive tooth wear—diagnosis and management. Clin Oral Investig. 2015 Jul 1;19(7):1557-61.
3. Sá Caye LF, Cerutti Kopplin D, Frasca LC da F, Rivaldo EG, Keller Celeste R. Prevalence and severity of tooth wear and risk factors among young adults in Southern Brazil. Rev Fac de Odontol Porto Alegre. 2020 Aug 20;61(1):38-47.
4. Ainoosah SE, Levon J, Eckert GJ, Hara AT, Lippert F. Effect of silver diamine fluoride on the prevention of erosive tooth wear in vitro. J Dent. 2020 May;103:100015.
5. Bartlett D, O'Toole S. Tooth wear and aging. Aust Dent J. 2019 May 30;64(S1):S59-62.
6. Sppezapria MS, Miranda MESG, Aguiar TRSA. A etiologia da lesão cervical não cariosa: um novo desafio para o cirurgião-Dentista do século XXI. Rev Nav Odontol. 2021; 48(1):41-9
7. Resende T, Reis K, Schlichting L, Magne P. Ultrathin CAD-CAM Ceramic Occlusal Veneers and Anterior Bilaminar Veneers for the Treatment of Moderate Dental Biocorrosion: A 1.5-Year Follow-Up. Oper Dent. 2018 Jul 1;43(4):337-46.
8. Uhlen MM, Tveit AB, Refsholt Stenhagen K, Mulic A. Self-induced vomiting and dental erosion – a clinical study. BMC Oral Health. 2014 Jul 29;14:92.
9. Schlueter N, Amaechi Bennett T, Bartlett D, Buzalaf M, Carvalho T, Ganss C, *et al*. Terminology of Erosive Tooth Wear: Consensus Report of a Workshop Organized by the ORCA and the Cariology Research Group of the IADR. Caries Res. 2020;54(1):2-6.
10. Butera A, Maiorani C, Gallo S, Pascadopoli M, Buono S, Scribante A. Dental Erosion Evaluation with Intact-Tooth Smartphone Application: Preliminary Clinical Results from September 2019 to March 2022. Sensors (Basel). 2022 Jul 8;22(14):5133.
11. O'Toole S, Marro F, Loomans BAC, Mehta SB. Monitoring of erosive tooth wear: what to use and when to use it. Br Dent J. 2023 Mar 24;234(6):463-7.
12. Canto FMT, Alexandria AK, Magno MB, Silva EM da, Maia LC. Topography and Microhardness Changes of Nanofilled Resin Composite Restorations Submitted to Different Finishing and Polishing Systems and Erosive Challenge. Pesqui Bras Odontopediatr Clín Integr. 2020;20:e4812.
13. Dundar A, Sengun A. Dental approach to erosive tooth wear in gastroesophageal reflux disease. Afr Health Sci. 2014 Jun 12;14(2):481.
14. Cruz JB, Bonini G, Lenzi TL, Imparato JCP, Raggio DP. Bonding stability of adhesive systems to eroded dentin. Braz Oral Res. 2015 Jul 7;29:S1806-83242015000100284.
15. de Queiroz Gonçalves PHP, Guimarães LS, de Azeredo FNA, Wambier LM, Antunes LAA, Antunes LS. Dental erosion' prevalence and its relation to isotonic drinks in athletes: a systematic review and meta-analysis. Sport Sci Health. 2020 Feb 22;16(2):207-16.
16. Nolasco SC, Rocha LC, Silva OS, Auad SM, Ferreira F, Assunção CM. Effects of different toothpaste formulations on erosive tooth wear prevention: systematic review. Braz Dent Sci. 2023 Jan 1;26(1):e3688-8.
17. Assunção CM, Lussi A, Rodrigues JA, Carvalho TS. Efficacy of toothpastes in the prevention of erosive tooth wear in permanent and deciduous teeth. Clin Oral Investig. 2018 May 2;23(1):273-84.
18. Maltarollo TH, Risemberg RICS, Pedron IG, Martins JL, Shitsuka C, Friggi MNP. Um guia rápido sobre o desgaste dentário erosivo. E-Acadêmica. 2022 May 22;3(2):e0732149.
19. Lourenço AR, Porto R, Lopes D, Moraes M, Rangel L, Azevedo MMF de, *et al*. Erosive potential associated with the pH of industrialized and natural drinks. Rev Flum

Odontol (Online). 2022;59(3):107-16 (Accessed on Nov 28th, 2023).
20. Souza PG, Machado AC, Pereira AG, Teixeira RR, Espíndola FS, Soares PV. The dentin chemical degradation and saliva roles on Noncarious Cervical Lesions – literature review. Rev Odontol Cienc. 2018 Jul 25;32(4):199-203.
21. Zimmer S, Kirchner G, Bizhang M, Benedix M. Influence of Various Acidic Beverages on Tooth Erosion. Evaluation by a New Method. Coles JA, editor. PLoS One [Internet]. 2015 Jun 2;10(6):e0129462.
22. Lussi A, Megert B, Shellis RP. The erosive effect of various drinks, foods, stimulants, medications and mouthwashes on human tooth enamel. Swiss Dent J [Internet]. 2023 Jul 10;133(7-8):440-55 (Accessed on Nov 28th, 2023).
23. Hartz JJ, Procopio A, Attin T, Wegehaupt FJ. Erosive Potential of Bottled Salad Dressings. Oral Health Prev Dent. 2021 Jan 1;19(1):51-7.
24. Chen WL, Chen YY, Wu WT, Lai CH, Sun YS, Wang CC. Examining relationship between occupational acid exposure and oral health in workplace. BMC Public Health. 2020 Sep 7;20(1):1371.
25. George R, Chell A, Chen B, Undery R, Ahmed H. Dental Erosion and Dentinal Sensitivity amongst Professional Wine Tasters in South East Queensland, Australia. Sci World J. 2014;2014:516975.
26. Ferraz LN, Pini NIP, Ambrosano GMB, Aguiar FHB, Lima DANL. Influence of cigarette smoke combined with different toothpastes on enamel erosion. Braz Oral Res. 2019 Dec 2;33:e114.
27. Baumann T, Kozik J, Lussi A, Carvalho TS. Erosion protection conferred by whole human saliva, dialysed saliva, and artificial saliva. Sci Rep. 2016 Oct 5;6:34760.
28. Stefański T, Postek-Stefańska L. Possible ways of reducing dental erosive potential of acidic beverages. Aust Dent J. 2014 Aug 22;59(3):280-8.
29. Aránguiz V, Lara JS, Marró ML, O'Toole S, Ramírez V, Bartlett D. Recommendations and guidelines for dentists using the basic erosive wear examination index (BEWE). Br Dent J. 2020 Feb;228(3):153-7.
30. Schmidt J, Huang B. Awareness and knowledge of dental erosion and its association with beverage consumption: a multidisciplinary survey. BMC Oral Health. 2022 Feb 11;22(1):35.
31. Agulhari MAS, Giacomini M, Rios D, Bombonatti J, Wang L. Giomer technology for preventive and restorative clinical management of erosive tooth wear: a case report. Braz Dent Sci. 2022;25(2):e3162.
32. Schlichting LH, Resende TH, Reis KR, Magne P. Simplified treatment of severe dental erosion with ultrathin CAD-CAM composite occlusal veneers and anterior bilaminar veneers. J Prosthet Dent. 2016 Oct;116(4):474-82 (Accessed on May 8th, 2019).
33. Morimoto S, Sesma N, Agra CM, Guedes-Pinto AC, Hojo KY. Erosão Dental: etiologia, mecanismos e implicações. J Biodent Biomater. 2017 Oct 20;4(1):6-23 (Accessed on Nov 29th, 2023).
34. Sato T, Fukuzawa Y, Kawakami S, Suzuki M, Tanaka Y, Terayama H, *et al*. The Onset of Dental Erosion Caused by Food and Drinks and the Preventive Effect of Alkaline Ionized Water. Nutrients. 2021 Sep 28;13(10):3440.
35. Chockattu SJ, Deepak BS, Sood A, Niranjan NT, Arun Jayasheel, Goud M. Management of dental erosion induced by gastro-esophageal reflux disorder with direct composite veneering aided by a flexible splint matrix. Restor Dent Endod. 2018 Jan 1;43(1):e13.
36. Mortensen D, Mulic A, Pallesen U, Twetman S. Awareness, knowledge and treatment decisions for erosive tooth wear: A case-based questionnaire among Danish dentists. Clin Exp Dent Res. 2020 Oct 30;7(1):56-62.
37. Grandon F, Marcus N, Muster M. Esthetic rehabilitation with ultra-thin ceramic veneers and direct mock-up in the treatment of dental erosion – case report. J Oral Res. 2018 Aug 1;7(6):194-9.
38. Schlichting LH, Resende TH, Reis KR, Raybolt dos Santos A, Correa IC, Magne P. Ultrathin CAD-CAM glass ceramic and composite resin occlusal veneers for the treatment of severe dental erosion: An up to 3-year randomized clinical trial. J Prosthet Dent. 2022 Aug;128(2): 158.e1-158.e12.
39. Sosa AC, Solis JM, Cruz-Fierro N, López S, Nakagoshi S. Dental Erosion: Causes, diagnostics and treatment. J Oral Res. 2014 Sep 24;3(4):257-61.
40. Khwaja Z, Millar BJ. An Analysis of Electronic Primary Dental Practice Tooth Wear Referrals. Prim Dent J. 2021 Mar;10(1):56-62.

LITERATURE REVIEW

FACTORS INFLUENCING FAILURES IN THE USE OF MINI-IMPLANTS: A LITERATURE REVIEW

FATORES QUE INFLUENCIAM INSUCESSOS NO USO DE MINI-IMPLANTES: UMA REVISÃO DE LITERATURA

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ABSTRACT

Temporary anchorage devices or mini-screws are becoming increasingly relevant in the clinical management of orthodontic treatments. However, despite the expressive clinical results obtained, some intercurrences may affect the anchorage during the treatment. Failures may be associated with factors related to the professional, the patient or the screw. Furthermore, there are factors that can contribute to the clinical success in the use of these devices, such as the appropriate selection of the length of the mini-screws, the choice of suitable areas for insertion of the device, such as areas of attached gingiva, besides the knowledge about bone density, aiming to contribute to primary stability, practice of good oral hygiene habits or even the use of self-drilling devices. Thus, the present study aimed to review the scientific literature available on mini-implants. Scientific articles were selected using PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar and Catalog of Theses and Dissertations. After applying the selection criteria, 32 articles were selected to compose this work. It is concluded that the use of mini-screws maintains ideal anchorage control, in order to avoid undesirable tooth movements, and the clinical success of temporary anchorage devices in Orthodontics is undeniable. However, it has been proven that complications whose etiology may vary between professionals, patients, or the screw itself are capable of affecting the device during orthodontic treatment, leading to failure of the mini-screws.

Keywords: Orthodontics; Mini-implant; Mini-screw; Micro-implants.

RESUMO

Os dispositivos de ancoragem temporária ou mini-implantes adquirem cada vez mais relevância no manejo clínico dos tratamentos ortodônticos. Entretanto, apesar dos resultados clínicos expressivos obtidos, algumas intercorrências podem acometer a ancoragem no decorrer do tratamento. Os insucessos podem estar associados a fatores relacionados ao profissional, ao paciente ou ao próprio parafuso. Outrossim, existem fatores que podem contribuir para o sucesso clínico na utilização destes dispositivos, como a seleção apropriada do comprimento do mini-implante, a escolha de áreas adequadas para inserção do dispositivo, além de conhecimentos acerca da densidade óssea, de forma a contribuir para a estabilidade primária, a prática de bons hábitos de higiene bucal ou ainda a utilização de dispositivos autoperfurantes. Assim, o presente estudo propôs-se a revisar a literatura científica disponível acerca de mini-implantes com artigos científicos selecionados utilizando as bases de dados PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar e Catálogo de teses e dissertações. Após aplicados os critérios de seleção, 32 artigos foram selecionados para compor este trabalho. Conclui-se que a utilização dos mini-implantes mantém o controle ideal da ancoragem, de modo a evitar movimentações dentárias indesejáveis, sendo inegável o sucesso clínico dos dispositivos de ancoragem temporária na Ortodontia. Entretanto, é comprovado que complicações cuja etiologia pode variar entre profissional, paciente ou o próprio parafuso são capazes de acometer a ancoragem no decorrer do tratamento ortodôntico, de modo a implicar falhas e insucesso dos miniparafusos.

Palavras-chave: Ortodontia; Mini-implante; Miniparafuso; Micro-implante.

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INTRODUCTION

In recent years, the use of mini-screws has resulted in a revolution in orthodontics, in which anchorage control is becoming more important in the clinical management of treatments (1) and an alternative to conventional methods (1,2). The ease with which the screws can be inserted and removed, their low cost, and the minimal need for patient cooperation (3) have made mini-implants popular, and their use has led to a significant reduction in anchorage loss rates in orthodontics (4).

Anchorage control is extremely important during orthodontic treatment. It avoids undesirable tooth movements resulting from the reaction of the forces applied to carry out the orthodontic movement (4,5).

Mini-screws are considered a safe, reliable, and efficient anchoring method (1). However, despite the significant clinical results obtained through its use, various complications can affect the anchorage during orthodontic treatment (4,6). The etiology of failure in this temporary anchorage may be associated with factors related to the professional, the patient or the screw (1,6). On the other hand, there are factors that can contribute to clinical success in the use of these devices, such as the appropriate choice of mini-implant length (5,7), the selection of more appropriate areas for insertion of the device, such as areas of attached gingiva (7), as well as knowledge about bone density (8, 9), the practice of good oral hygiene habits (3,9,10) or the use of self-drilling devices (11).

This study aimed to review and analyze the available scientific literature on using mini-implants to clarify the conditions that may influence these orthodontic devices' clinical success or failure rate. For this reason, identifying this etiology is extremely important to minimize clinic failures and help increase success rates.

LITERATURE REVIEW

The eligibility criteria were established based on studies that evaluated the factors that interfere with the clinical success of temporary anchorage devices in orthodontics. Observational, interventional, review, and case series studies were included. Expert opinions, editorials, and letters were excluded though.

The scientific literature was reviewed in electronic databases: PubMed, Scopus, Web of Science, Cochrane Library, Embase, BVS, Opengrey, Google Scholar and Catalog of Theses and Dissertations in May 2023. The search strategy was initially developed for MEDLINE (PubMed), using MeSH terms, entry terms, and free terms where possible. The combination of terms included was: "Orthodontics", "Mini-implant", "Mini-screw", "Micro-implants" and "Mini implants success rate" and their derivatives, adapted according to each database and for each language, as well as adjusted for the other databases according to their syntax rules.

To improve the searches, the Boolean operators "OR" and "AND" were combined. No restrictions were placed on the date of publication or language. Two authors (L.T.V. and B.C.T.B.) independently assessed the title and abstract of all the articles retrieved from the databases. The duplicates were then removed manually. Observational, interventional, review, and case series studies were included, excluding those with expert opinions, editorials, and letters. A total of 55 articles were selected for full reading. After reading, 32 articles met the criteria for this review. Articles that did not meet the eligibility criteria were excluded at this stage. In the event of disagreement between the authors, a third author (M.M.G.S), an expert in the field, was consulted.

A total of 12,381 articles were retrieved (PubMed = 428, Scopus = 793, Web of Science = 962, Cochrane Library = 234, Embase = 869, BVS = 1, Opengrey = 0, Google Scholar = 9,050 and Catalog of Theses and Dissertations = 44). Of these, 32 articles were selected to make up this review, after removing duplicates, reading titles, abstracts and reading in full.

Table 1 shows the selected studies and their respective themes regarding the etiology of mini-implant failure.

Professional-related factors

It is essential for the clinician to plan the appropriate site for inserting the mini-implant to guarantee the effectiveness and success of the intervention. Therefore, knowledge about bone density in specific areas of the oral cavity can be extremely useful (12). Mainly to avoid damage to adjacent tissues or root injuries due to improper insertion of mini-screws (3). Van Mai Truong *et al*. state that the professional must understand the insertion and removal procedures in full, as well as mastering the characteristics of the anatomical structures and the inherent characterization of the screw, to maximize the success and effectiveness of the procedure (8). According to Kim *et al*., when evaluating mini-implant insertion methods, success rates were similar among all age groups of patients regardless of the technique used (13).

There is a learning curve about the successful insertion of temporary anchorage devices. At the same time, the failure rates related to orthodontic mini-implants are inversely proportional to the increase in clinical experience (14).

TABLE 1. ARTICLES USED AND THEIR RESPECTIVE THEMES REGARDING CLINICAL SUCCESS USING MINI-IMPLANTS.

Author, Year, and Type of Study.	Professional related factors.	Patient-related factors.	Screw-related factors.
Apel *et al*. (2009) - Clinical trial		■	
Baek *et al*. (2008) - Clinical trial		■	
Casaña-Ruiz *et al*. (2020) - Systematic review and meta-analysis		■	
Chaddad *et al*. (2008) - Clinical trial			■
Chen *et al*. (2007) - Clinical trial		■	
Chin *et al*. (2007) - Clinical trial			■
Chugh *et al*. (2013) - Literature review	■	■	
da Cunha *et al*. (2015) - Experimental study		■	■
Dalessandri *et al*. (2014) - Meta-analysis		■	
Garfinkle *et al*. (2008) - Clinical trial	■	■	
Giudice *et al*. (2021) - Systematic review		■	
Holm *et al*. (2012)		■	
Kim *et al*. (2012) - Clinical trial	■		
Knutson *et al*. (2013) - Experimental study			■
Kravitz *et al*. (2007) - Literature review		■	■
Leo *et al*. (2016) - Literature review	■	■	■
Malik *et al*. (2023) - Literature review		■	
Marquezan *et al*. (2014) - Experimental study		■	
Manni *et al*. (2011) - Experimental study		■	■
Melo *et al*. (2016) - Clinical trial		■	
Mohammed *et al*. (2018) - Systematic review and meta-analysis		■	
Papadopoulos *et al*. (2011) - Meta-analysis		■	
Papadopoulos *et al*. (2007) - Literature review	■	■	
Papageorgiou *et al*. (2012) - Meta-analysis		■	
Pithon *et al*. (2013) - Clinical trial			■
Reynders *et al*. (2009) - Systematic review	■	■	■
Romano *et al*. (2015) - Clinical trial		■	
Severo *et al*. (2015) - Literature review	■	■	■
Suzukia *et al*. (2011) - Clinical trial			■
Truong *et al*. (2022) - Literature review	■		
Tsai *et al*. (2016) - Clinical trial		■	
Wu *et al*. (2009) - Clinical study		■	

Patient-related factors

In general, mini-screws are biologically compatible with the patient's body, but it is essential that professionals understand the need for them and carry out a meticulous assessment, taking into account each individual's biological environment (1), careful technique, and accurate planning (15).

The choice of anatomical location should minimize any risk of root contact or the insertion of screws in areas with nerves or vessels (1). Mohammed *et al*. points out a greater risk of failure in mini-screws that came into contact with the roots (16). This unwanted event also had a higher incidence in the posterior region of the arches, equally affecting the maxilla and mandible (17).

Regarding the bacterial flora, the screws are placed transgingivally so that they are accessible to numerous types of microorganisms in the oral cavity, especially bacteria associated with periodontitis and peri-implantitis. In patients with poor oral hygiene, these bacteria can penetrate the tissues through the devices, triggering infections of soft and/or mineralized tissues (18). The patient's peri-implant tissues can be affected by irritation or inflammation, resulting in mini-screw failure, especially in patients with poor oral hygiene (4,19). Kravitz and Kusnoto equated the importance of home hygiene care for mini-screws with the importance of proper placement of the device by the orthodontist (9). In the study by Apel *et al*., bacterial analyses were carried out to investigate the clinical failure rate of mini-screws, and no significant differences were identified in the total quantity or species composition between the mini-screws in the clinically successful group and those characterized by failure. However, the species Actinomyces viscosus was found in 100% of cases and Campylobacter gracilis in 75% of stable screws, while both species were rarely detected in failed temporary anchorage devices (12.5%) (18). Furthermore, Melo *et al*. pointed out that factors such as smoking habits and craniofacial pattern did not affect the success of temporary anchorage devices (20).

No difference in mini-implant failure rates was observed based on the patient's age group (20,21). On the other hand, Chen *et al*. observed that mini-implants inserted in younger patients have a higher risk of failure (22), and Dalessandri *et al*. noted that the effectiveness of mini-screws is greater when used in individuals over 20 years of age (19). Meanwhile, Wu *et al*. showed a higher failure rate in elderly patients (10).

Bone density is a fundamental factor when installing temporary anchorage devices (9,12), since areas of low bone density may indicate the need for longer mini-implants to improve retention.

In areas of high bone density, pre-drilling can act as a preventative measure against possible screw fractures (12). Besides, Cunha *et al*. stated that the mechanical performance of temporary anchorage devices is highly dependent on the quality of the bone substrate (23). It should be noted that areas of greater bone density require adequate irrigation to prevent bone overheating during device installation (12). Considering bone properties, Marquezan *et al*. reported that cancellous bone plays a fundamental role in the primary stability of mini-screws, whether in the presence or absence of cortical bone. In addition, the primary stability of the anchorage device is directly dependent on the bone mineral density of the recipient site (24).

According to Holm *et al*., the increase in cortical bone density generates a significant increase in the maximum insertion torque, which increases the primary stability of the mini-implant (25). When it comes to the ideal position for inserting temporary anchorage devices, the highest success rate is found in the inserted gingiva (85.4%), followed by insertion in the mucogingival line (84.2%) (26). Moreover, Kravitz and Kusnoto stated that the absence of inserted gingiva at the mini-implants insertion site is a potential risk factor (9). When considering the distinctions between the placement of the temporary anchorage device on the right and left side, no significant differences were observed in the failure rates of the mini-implant on the insertion side (21). These results corroborate the findings of studies by Baek *et al*. (27). Manni *et al*. compared the success rate of mini-screws when inserted in the maxilla and mandible. They concluded that the highest success rate (86.9%) occurred in the maxilla, compared to 76.1% of devices inserted in the mandible (26). Similarly, the study by Papageorgiou *et al*. highlights that the highest failure rates were found in mini-implants inserted in the mandible (19.3%) (21). These results corroborate those found by Dalessandri *et al*, Chen *et al*, Melo *et al* and Casaña-Ruiz *et al* (19,20,22,28).

Screw-related factors

Pithon *et al*. evaluated the length of the mini-implant and its interferences. They reported that the length of the screw does not influence the fracture resistance during bending of the device. However, increasing the length of the screw, despite not generating an increase in mechanical strength, can effectively contribute to reinforcing initial stability (5).

Surface characteristics do not influence the survival rates of immediately loaded mini-implants (29). However, Knutson and Berzins suggest that the corrosion of orthodontic mini-screws contributes to tissue inflammation, becoming one of the agents that interfere with the clinical success of the devices. Furthermore, the authors point out that exposing screws to fluoride reduces polarization resistance and increases the corrosion current of the devices (30).

Mini-implants' geometry is a fundamental factor that directly influences the distribution of stresses on the bone. Excessive stress between the bone's interface and the device is a major cause of mini-screw failures (9,23).

Regarding the types of mini-implants, self-drilling devices have numerous advantages over pre-drilled ones. The first devices provide the simplest surgical procedures for placement and offer greater primary stability compared to pre-drilled mini-screws. Self-drilling mini-implants are less resistant to osseointegration because they are temporary anchoring devices that require easy removal with a low risk of fracture (11).

The literature shows that success rates are over 80% and that the adverse effects of mini-implants include biological damage, inflammation, painful symptoms, and discomfort (31).

The skeletal anchorage system presents miniplates as an alternative to mini-implants as a resource for anchorage control. These are pure titanium or titanium alloy anchorage plates temporarily implanted in the maxilla or mandible as absolute orthodontic anchorage. They have excellent mechanical strength and promote effects on the bone surface, contributing to a higher anchorage value and better stability of the miniplates, among other temporary anchorage devices. However, miniplates are expensive and require a more invasive surgical procedure than mini-implants, since it requires a flap opening (32-34).

DISCUSSION

Wu *et al*., Papageorgiou *et al*., Chen *et al*. and Melo *et al*. state that the failure rate of mini-implants was not significantly affected by the age or sex of the individual (10, 20-22). However, when considering the sexes, Manni *et al*. point out that there are differences and the success rate is higher in males (88%) when compared to females (26). Malik *et al*. confirm that, like bone quality, gender is a determining factor and impacts clinical practice, with the success of temporary devices being greater in females (35). In a systematic review, Casaña-Ruiz *et al*. noted that the gender variable has been the subject of controversy, since some studies report that the gender of patients does not interfere with the failure of treatment with mini-implants, while other studies have attributed a higher success rate to male individuals, due to the greater bone density of men (28).

According to the findings of Papadopoulos *et al*., the patient's role in orthodontic treatment with a temporary anchorage device is limited to cooperation in maintaining adequate and effective oral hygiene (3). About patient adherence to treatment, Wu *et al*. emphasized the importance of collaboration in preventing inflammation around the screws for the treatment to be successful (10). Wu *et al*. also showed that hygiene habits can affect the risk of losing a mini-screw (10).

According to Pithon *et al*. regarding the length of the mini-implant and its respective interferences, the length of the screw does not influence the resistance to fracture during bending of the device. However, a screw with a longer length can help to reinforce initial stability (5). However, in line with the findings of Manni *et al*., the length of the mini-screw is relevant, with a device 1.3 mm wide and 11 mm long being considered the best performing (26).

In a systematic review, Reynders *et al*. reported that most studies show success rates of over 80% and that the unfavorable consequences include biological damage, inflammation, painful symptoms, and discomfort (31). Papadopoulos *et al*. corroborate these findings, pointing out that orthodontic mini-screws used for anchorage purposes have a success rate of 87.7%. Melo *et al*. corroborate the previous findings (20).

Van Mai Truong *et al*. emphasize the importance of the professional knowing and mastering the procedures for inserting and removing the devices, as well as the characteristics of the anatomical structures and the characterization of the screw, to carry out an effective and satisfactory procedure (8). These findings are corroborated by the study by Honsali *et al*. evaluating a digitally assisted mini-implant insertion system, which highlights the importance of investigating and knowing the screw insertion area and considering factors inherent to the individual, such as ethnicity, sex, and anatomical characteristics (36).

CONCLUSION

Mini-screws have transformed orthodontic anchorage, acquiring greater relevance in the clinical management of treatments with significant success. However, complications caused by the professional, the patient or the screw itself can affect the device in orthodontic treatment. The clinician needs to know the specific areas of the oral cavity where the mini-screws will be inserted, the inherent characteristics of the anatomical structures, to carry out good planning, as well as to master the knowledge of the screw to maximize the success of the procedure. It should be noted that there is a learning curve for professionals about the success of temporary anchorage devices. Mini-screws are compatible with the body, but the patient's cooperation in maintaining proper oral hygiene over the long term is essential to minimize the risk of losing the device or the risk of infection. There is controversy over whether the length of the mini-implant contributes to the procedure's success. However, it is well known that the geometry of the mini-screws is a fundamental factor that has a direct influence on the distribution of stresses on the bone and, consequently, on the device's success.

The authors declare that there are no conflicts of interest.

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REFERENCES

1. Leo M, Cerroni L, Pasquantonio G, Condò SG, Condò R. Temporary anchorage devices (TADs) in orthodontics: review of the factors that influence the clinical success rate of the mini-implants. Clin Ter. 2016;167(3):e70-7.
2. Chin MY, Sandham A, de Vries J, Van der Mei HC, Busscher HJ. Biofilm formation on surface characterized micro-implants for skeletal anchorage in orthodontics. Biomaterials. 2007;28(11):2032-40.
3. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: A comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(5):e6-15.
4. Papadopoulos MA, Papageorgiou SN, Zogakis IP. Clinical Effectiveness of Orthodontic Miniscrew Implants: a Meta-analysis. J Dent Res. 2011;90(8):969-75.
5. Pithon MM, Figueiredo DS, Oliveira DD. Mechanical evaluation of orthodontic mini-implants of different lengths. J Oral Maxillofac Surg. 2013;71(3):479-86.
6. Severo FC, Barbosa GF. Risk factors and success rates associated with orthodontic mini-implants: a literature review. Rev Odonto Cienc. 2015;30(4):200-4.
7. Manni A, Cozzani M, Tamborrino F, De Rinaldis S, Menini A. Factors influencing the stability of miniscrews. A retrospective study on 300 miniscrews. Eur J Orthod. 2011;33(4):388-95.
8. Truong VM, Kim S, Kim J, Lee JW, Park YS. Revisiting the Complications of Orthodontic Miniscrew. Biomed Res Int. 2022;1;2022:8720412.
9. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop. 2007;131:S43-S51.
10. Wu TY, Kuang SH, Wu CH. Factors associated with the stability of mini-implants for orthodontic anchorage: a

study of 414 samples in Taiwan. J Oral Maxillofac Surg. 2009;67(8):1595-9.
11. Suzukia EY, Suzukia B. Placement and removal torque values of orthodontic miniscrew implants. J Orthod Dentofacial Orthop. 2011;139(5):669-78.
12. Chugh T, Jain AK, Jaiswal RK, Mehrotra P, Mehrotra R. Bone density and its importance in orthodontics. J Oral Biol Craniofac Res. 2013;3(2):92-7.
13. Kim JS, Choi SH, Cha SK, Kim JH, Lee HJ, Yeom SS, *et al*. Comparison of success rates of orthodontic mini-screws by the insertion method. Korean J Orthod. 2012;42(5):242-8.
14. Garfinkle JS, Cunningham LL Jr, Beeman CS, Kluemper GT, Hicks EP, Kim MO. Am J Orthod Dentofacial Orthop Evaluation of orthodontic mini-implant anchorage in premolar extraction therapy in adolescents. 2008;133(5):642-53.
15. Romano FL, Consolaro A. Why are mini-implants lost: The value of the implantation technique!. Dental Press J. Orthod. 2015;20(1):23-9.
16. Mohammed H, Wafaie K, Rizk MZ, Almuzian M, Sosly R, Bearn DR. Role of anatomical sites and correlated risk factors on the survival of orthodontic miniscrew implants: a systematic review and meta-analysis. Prog Orthod. 2018;24;19(1):36.
17. Giudice AL, Rustico L, Longo M, Oteri G, Papadopoulos MA, Nucera R. Complications reported with the use of orthodontic miniscrews: A systematic review. Korean J Orthod. 2021;25;51(3):199-216.
18. Apel S, Apel C, Morea C, Tortamano A, Dominguez G C, Conrads G. Microflora associated with successful and failed orthodontic miniimplants. Clin Oral Impl Res. 2009;20(11):1186-90.
19. Dalessandri D, Salgarello S, Dalessandri M, Lazzaroni E, Piancino M, Paganelli C, *et al*. Determinants for success rates of temporary anchorage devices in orthodontics: a meta-analysis (n > 50). Eur J Orthod. 2014;36(3):303-13.
20. Melo AC, Andrighetto AR, Hirt SD, Bongiolo AL, Silva SU, Silva MA. Risk factors associated with the failure of miniscrews - A ten-year cross sectional study. Braz Oral Res. 2016;24;30(1):e124.
21. Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated risk factors of orthodontic miniscrew implants: a meta-analysis. Am J Orthod Dentofacial Orthop. 2012;142(5):577-595.e7.
22. Chen YJ, Chang HH, Huang CY, Hung HC, Lai EH, Yao CC. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. Clin Oral Implants Res. 2007;18(6):768-75.
23. da Cunha AC, Marquezan M, Lima I, Lopes RT, Nojima LI, Sant'Anna EF. Influence of bone architecture on the primary stability of different mini-implant designs. Am J Orthod Dentofacial Orthop. 2015;147(1):45-51.
24. Marquezan M, Lima I, Lopes RT, Sant'Anna EF, de Souza MM. Is trabecular bone related to primary stability of miniscrews?. Angle Orthod. 2014 May;84(3):500-7.
25. Holm L, Cunningham SJ, Petrie A, Cousley RR. An in vitro study of factors affecting the primary stability of orthodontic mini-implants. Angle Orthod. 2012;82(6):1022-8.
26. Manni A, Cozzani M, Tamborrino F, De Rinaldis S, Menini A. Factors influencing the stability of miniscrews. A retrospective study on 300 miniscrews. Eur J Orthod. 2011;33(4):388-95.
27. Baek SH, Kim BM, Kyung SH, Lim JK, Kim YH. Success rate and risk factors associated with mini-implants reinstalled in the maxilla. Angle Orthod. 2008;78(5):895-901.
28. Casaña-Ruiz MD, Bellot-Arcís C, Paredes-Gallardo V, García-Sanz V, Almerich-Silla JM, Montiel-Company JM. Risk factors for orthodontic mini-implants in skeletal anchorage biological stability: a systematic literature review and meta-analysis. Sci Rep. 2020 Apr 3;10(1):5848.
29. Chaddad K, Ferreira AF, Geurs N, Reddy MS. Influence of surface characteristics on survival rates of mini-implants. Angle Orthod. 2008;78(1):107-13.
30. Knutson KJ, Berzins DW. Corrosion of orthodontic temporary anchorage devices. Eur J Orthod. 2013;35(4):500-6.
31. Reynders R, Ronchi L, Bipat S. Mini-implants in orthodontics: a systematic review of the literature. Am J Orthod Dentofacial Orthop. 2009;135(5):564.e1-19.
32. Sherwood KH, Burch JG, Thompson WJ. Closing anterior open bites by intruding molars with titanium miniplate anchorage. Am J Orthod Dentofacial Orthop. 2002;122(6):593-600.
33. Sugawara J, Baik UB, Umemori M, Takahashi I, Nagasaka H, Kawamura H, *et al*. Treatment and posttreatment dentoalveolar changes following intrusion of mandibular molars with application of a skeletal anchorage system (SAS) for open bite correction. Int J Adult Orthodon Orthognath Surg. 2002;17(4):243-53.
34. Sugawara J. Temporary skeletal anchorage devices: the case for miniplates. Am J Orthod Dentofacial Orthop. 2014 May;145(5):559-65.
35. Malik F, Khan F, Ali S, Rana F, Haq H, Hussain M. Factors affecting success and failure of orthodontic mini-implants: A retrospective review. Professional Med J. 2023;30(02):285-91.
36. El Honsali Y, Ben Mohimd H, Zaoui F, Benyahia H. Contribution of digital technology to the surgical technique of miniscrew insertion: a literature review. Nav Dent J. 2023;50(2):31-8.

LITERATURE REVIEW

SHORT AND ULTRASHORT IMPLANTS UNDER IMMEDIATE LOADING IN EDENTULOUS AND ATROPHIC JAWS – A LITERATURE REVIEW

IMPLANTES CURTOS E ULTRACURTOS SOBRE CARGA IMEDIATA EM ESTRUTURAS ÓSSEAS EDÊNTULAS E ATRÓFICAS – UMA REVISÃO DE LITERATURA

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ABSTRACT

Planning prosthetic rehabilitation in cases of edentulism in atrophic bone structures embraces a high and extensive complexity. Supported implants require a thick bone which accommodates the implant fixation functionally and, in cases of bone atrophy, rehabilitation with conventional implants (10mm) is based on surgical techniques to increase the ridge, which are more invasive and present greater risks. Currently, the literature presents short (<10mm) and ultrashort (4mm) implants as a safer and more economical alternative, which has shown an efficiency and good prognosis. The objective of this study is to evaluate the survival rates of total prosthesis on short/ultrashort implants with immediate loading in atrophic bone structures. In most cases, immediate loading has been a prerequisite for patients and the results have been promising. The surface treatment of the implant linked to detailed prosthesis' planning makes this condition viable. However, not only primary stability is what determines clinical success, but also bone biological response and the number of implants to be installed.

Keywords: Survival rate; Dental implants; Immediate loading; Edentulous jaw; Bone loss.

RESUMO

Planejar uma reabilitação protética nos casos de edentulismo em estruturas ósseas atróficas envolve uma alta e extensa complexidade. Os implantes-suportados precisam de uma espessura óssea que acomode a fixação do implante funcionalmente e, nos casos de atrofia óssea, reabilitações com implantes convencionais (10mm) envolvem técnicas cirúrgicas de aumento do rebordo, que são mais invasivas e apresentam maiores riscos. Atualmente, a literatura apresenta os implantes curtos (<10mm) e ultracurtos (4mm) como uma alternativa mais segura e econômica, que tem mostrado eficiência e um bom prognóstico. O objetivo deste estudo foi avaliar as taxas de sobrevivência de próteses totais sobre implantes curtos/ultracurtos com carga imediata em estruturas ósseas atróficas. Na maioria dos casos, o carregamento imediato tem sido um pré -requisito para os pacientes e os resultados têm sido promissores. O tratamento de superfície do implante atrelado a um minucioso planejamento da prótese, viabilizam esta condição. Entretanto, o que determina o sucesso clínico é a estabilidade primária, a resposta biológica óssea e o número de implantes a serem instalados.

Palavras-chave: Taxa de sobrevivência; Implantes dentários; Carregamento imediato; Mandíbula edêntula; Perda óssea.

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INTRODUCTION

Dental implants are an option for patients with edentulous areas, for whom fixed or removable partial dentures were once the only viable option (1). In 1969, Branermark revolutionized the history of osseointegrated implants, and since then, they have evolved to improve patients' aesthetic and functional standards (2).

Cases of edentulism involve greater complexity due to anatomy and functionality (3). Early teeth loss, periodontal disease, and long-term use of removable prostheses can cause bone atrophy, making oral rehabilitation with conventional length implants (10mm) difficult because they cause risks to more noble areas and chance of fractures (4). Although bone grafting, maxillary sinus lift, or repositioning of the inferior alveolar nerve are alternatives for increasing bone volume, the high cost and morbidity risks are unfavorable (5).

Short and ultrashort implants have shown excellent results as an alternative for these patients (6). A study based on randomized clinical trials, with a follow-up of 1 to 5 years, to evaluate the survival rate of 637 short implants and 653 standard-length implants concluded that the prognosis of short implants was more favorable (86.7% to 100%) and with a lower post-surgical complication rate compared to conventional implants associated with bone grafting (95% to 100%) (6).

Researchers are still studying the use of immediate loading since its applicability can affect the survival rate of implants, but this does not interfere with the final success of the prosthesis. The correct distribution of occlusal forces in the period after implant insertion has a direct influence on good results (7).

A favorable prognosis is based on the primary stability of the implant and pre-prosthetic design/planning based on the patient's masticatory dynamics so that possible unfavorable occlusal forces do not affect the implants (8). In addition, the combination of surface treatment and the factors above enables immediate loading, which has become a prerequisite among patients today (8). However, trans/post-operative success depends mainly on the biological response of the bone and the number of implants to be installed (9).

Most studies have reported that the survival rate of short/ultrashort implants installed with immediate or delayed loading supporting single crowns ranges from 94% to 98% (10-15). The aim of this study is to gather case reports and studies on the current use of short/ultrashort implants on immediate loading in atrophic bone structures, prosthesis survival rates in full-arch rehabilitation, success rates in biomechanics, surgical planning, and longevity in prosthetic rehabilitation for individuals with resorbed alveolar ridges.

MATERIALS AND METHODS

The present literature review is based on a critical and systematic analysis conducted through research carried out on the subject between August and October 2023. The research was conducted on electronic databases such as Google Scholar, Scielo, and PubMed. Titles and abstracts were screened by two examiners using the descriptors: "Survival Rate", "Dental Implants", "Immediate Loading", "Edentulous Jaw", and "Bone Loss", resulting in the selection of 46 case reports and scientific articles on short and ultrashort implants in edentulous and atrophic regions under immediate loading, in both Portuguese and English languages, published between 2012 and 2023. Studies focusing on unitary prosthetic rehabilitation with these implants or those not mentioning immediate loading as part of the treatment were excluded.

LITERATURE REVIEW

Short implants

In 1979, the first short 7mm Standard implants were installed as a unit or in conjunction with long implants due to the demand from patients with jaws with a reduced ridge. Its features were like those of the conventional (10mm), and it had no characteristics that guaranteed its success after launch. Currently, reduced-size implants have different specificities, such as cutting and compacting apexes, which help with stability in reduced bone beds, progressive threads along the implants for bone compaction, and a large treatment surface area, which is of fundamental importance for their clinical performance (16).

Some authors conceptualize short implants as those between 7 and 10mm, while others define them as 8mm or smaller than 8.7 or 6mm (17-19). Still, other researchers claim that ultra-short implants are 4mm long (20-22). The main advantages of their clinical use are shorter treatment times, less need for bone grafting and other more invasive techniques, lower costs, less discomfort for the patient, and lower surgical risks (10).

Most of the stresses from occlusal forces acting on the prosthesis are concentrated in the cortical bone around the implant platform, justifying the use of increasingly shorter implants since length is not the most important factor for clinical success (23). Using them as a treatment option has contributed to

a more conservative and effective treatment, even though short implants are not immune to failure (24).

In atrophic ridge rehabilitation, short implants are characterized as a treatment option when more complex surgical treatments are not considered (23). The longevity of implants is linked to their success and meeting the ideal clinical protocol, giving importance to biomechanical factors during their installation (7). The implant is considered satisfactory when there is no mobility, signs or symptoms of inflammation, peri-implantitis, infection, or paresthesia. In the long term, vertical loss of up to 0.2mm per year can be observed in successful implants (25).

Advances in implant surface treatment have made it possible to reduce their size without losing their stability and function (25). Studies have reported the direct influence of surface treatment and design modification on osseointegration success (8, 9,1,25-27). The reason for this is that due to the rough surface of the implant, osteoblasts can adhere to it more quickly. The most widely used methods for increasing roughness are surface blasting and acid etching, which combine sandblasting and acid etching (26,27).

It is worth noting that, in addition to the advantages that short implants provide, the crown/implant ratio can be a biomechanical disadvantage since the long crown can act as a vertical cantilever, which increases the forces from chewing (11). Furthermore, regions with bone beds composed of a thin cortical layer in the crest involving dense trabecular bone inside (type III) or low density (type IV) are more susceptible to failure, even if the implant has received surface treatment. The reduced height of the implant, combined with poor bone quality, compromises primary stability and osseointegration (25).

Longevity in prosthetic rehabilitation in atrophic regions

There is little evidence regarding the longevity of short implants on immediate loading and their advantages in atrophic regions since durability and success depend intrinsically on the patient's bone conditions (quality and density) and systems (8). Despite the advances in dentistry in the prosthetic rehabilitation of totally or partially edentulous patients, there are still limitations regarding the crown-implant ratio, reduced aesthetics due to extensive vertical loss, and early implant loss (9).

The critical points of full-arch rehabilitation with ultra-short implants occur between the first week and four months after loading. Immediate loading can directly affect implant survival but not the result of the prosthesis since the correct occlusal distribution in the implant/bone relationship is important for clinical success (17). Herein, thorough planning must include facial and occlusal assessment procedures and bone quality (28). However, short implants may be contraindicated in systemic diseases that could compromise tissue healing or regenerative capacity and in cases of radiotherapy on the edentulous region (12). A study to evaluate marginal bone loss, implant, and total prosthesis survival on 18 patients with severe mandibular atrophy, aged between 40 and 77 years, revealed that systemic disorders were challenging for implant survival in regions of high bone resorption. On the other hand, reconstruction on four ultra-short implants showed good survival rates and bone stability, encouraging its use (29).

Reverse planning is based on solving the patient's needs through investigations, which are carried out through a detailed anamnesis, intra- and extra-oral examinations assessing the health of the mucosa, remaining teeth, prosthetic space, as well as occlusal analysis, diagnostic wax-up, imaging tests and a surgical guide (30). The work becomes predictable and easier when the prosthetic preparation begins, which is why it is called reverse planning. For treatment to progress with a good prognosis, multidisciplinary work is essential, verifying the need for endodontic, orthodontic, surgical, or periodontal treatment before surgery (31).

Using surgical guides also reduces the chances of failure, allowing the most suitable implant position to be visualized to achieve aesthetic, phonetic, and functional results. This factor corroborates the longevity of prosthetic rehabilitations in atrophic regions (31).

Immediate loading

Implant dentistry, with immediate loading protocols, provides oral rehabilitation quickly and, consequently, provides patients with greater comfort and aesthetics since implants and prostheses can be installed at the same time as surgery (32).

The osseointegration protocol stipulates that after the surgical procedure for implantation and osseointegration, the implant must remain unloaded for a period of three to six months, as fibrous tissue can form around it, leading to a loss of support during the healing phase (33). Nevertheless, clinical studies and authors have reported success in experiments with short implants on immediate loading in atrophic bone structures, showing that early activation does not interfere with treatment prognosis (13,33-37). The survival rates of short dental implants are quite high, on average 91-97% in patients with generalized aggressive periodontitis and 100% in periodontally healthy patients (34).

The main advantages of the technique are reduced waiting times, aesthetics, and reduced trauma for the patient (10). Even though, to achieve success, factors such as surface treatment, biocompatibility, load control, bone quality, and surgical technique are of great value in determining osseointegration (33). Some principles also need to be considered during the healing phase: any type of movement of the implant is contraindicated; all loads must be directed axially; and, in addition to bone quality being relevant, it is recommended that the implant be installed in bone with good stability, preferably in the anterior region of the mandible (35).

Performance in clinical practice

The first study with 4mm ultra-short implants on immediate loading was based on two years of follow-up. The aim was to assess whether this type of rehabilitation would be an option for patients with an edentulous atrophic mandible. Four 4mm ultra-short implants (pure titanium, rough surface with transmucosal design) were used directly in the interforaminal region. The prosthesis avoided laterality and canine guides to balance and mutual occlusal protection. As a result, peri-implant marginal bone levels, osseointegration, and clinical prosthetic performance showed stability and efficacy (36).

To evaluate the survival rate under immediate loading in mandibular atrophy, 114 ultra-short twinKon®4 implants with a surface roughness of 1-2 µm were installed in 19 patients. The cases were followed up for three years, and during the first four months after installation, ten implants failed to osseointegrate. There were no further losses after the period. Overall, the survival rate was 87%. Sixteen of the 114 implants were lost, but this did not interfere with the final success of the prosthesis, which remained stable with at least four ultra-short implants in 18 of the 19 patients (17).

Advancing age and tooth loss directly influence alveolar bone resorption (28). This study was carried out on a 70-year-old patient who reported dissatisfaction with her lower total prosthesis and an atrophic mandible. Four short Neodent Titamax Cone Morse—CM, 5 x 7mm implants were installed in the mandible with immediate loading, and a removable total prosthesis was installed in the maxilla. The study was carried out over five years, with annual esthetic-functional evaluation showing satisfactory results (13).

When a thorough planning and clinical protocol is carried out, positive results are achieved in rehabilitating atrophic posterior regions with short implants (37). The case addresses the treatment of a 53-year-old patient who complained of chewing difficulties and the adaptation of a lower total prosthesis. Clinical and imaging examination revealed a severely reduced mandible height. Four implants were installed with immediate loading following a rigid surgical protocol, two measuring 3.75x7mm and the other 3.75x8mm. The study lasted 12 months, and only a small amount of saucerization was identified without compromising the efficacy of the treatment (16).

Another study included four patients whose jaws showed extensive bone atrophy. They received surgical treatment for the implantation of 16 short implants ranging from 7.5 to 10mm and a protocol prosthesis. One of these patients was unsuccessful, and his implant was replaced by another in immediate loading, with a success rate of 94.12%. The implants were followed up for 36 months, and there was no implant loss, only perimplant bone loss of 0.71mm, which was within normal standards (15).

A case report evaluated the prosthetic rehabilitation of a 71-year-old patient. She had pain when closing her mouth in the projection of the mental foramen due to severe bone atrophy close to the inferior alveolar nerve. The rehabilitation was fully guided with four short implants measuring 4 x 7mm in diameter installed in the mandible region at an angulation of 29°. As a result, it was possible to perform a minimally invasive, flap-free, fully guided surgery, reducing the risk of possible operative complications and with a favorable prognosis. The patient was still being followed up every six months (34).

One study evaluated 6 cases of short implants (8mm) in total cases, obtaining data on marginal bone loss, proportion of implant failure, biological complications, and risk factors. Two hundred ninety-one short implants (5 to 8 mm) were installed in 122 patients, supporting 23 fixed prostheses and 99 removable full-arch prostheses. In the fixed cases, marginal bone loss was 0.11mm with a prevalence of 34.5% in prosthetic complications; in removable cases, 0.14mm of resorption was 2.6% of prosthetic-related complications. As a result, the survival rate of short implants was 97.7%, compared to conventional implant rehabilitations in grafted bone (96% of survival rate). The risk factors showed no statistically significant differences in the proportion of implant failure and marginal bone loss (34).

DISCUSSION

The treatment plan for rehabilitation with dental implants requires meticulous attention to anatomical characteristics and assessing bone quantity, quality, thickness, and density (8,9,25). The continuous use of removable prostheses triggers resorption of the alveolar ridge. At the same time, the absence of

dental elements tends to reduce bone height, making it more difficult to install conventional implants in this region (12).

Thus, rehabilitation in mandibles with conventional implants at a height of less than 12mm is highly questionable because they do not provide sufficient retention and bring greater risks of morbidity to the patient (12). Furthermore, they refer to a type of protocol that requires more skill on the part of the professional and a longer treatment time. They can also be more expensive due to more complex surgeries involving biomaterial grafting, lateralization of the inferior alveolar nerve, or implants positioned in unconventional ways (25). Therefore, short implants are a more accessible and safer option for rehabilitating atrophic edentulous areas and also prevent risks to noble areas or fractures during the complex surgical techniques mentioned above (27,33). They are indicated for bone scarcity (10,24,37). On the other hand, studies show that the most suitable areas are the jaws' posterior regions, and their results are similar to conventional implants (12,14,37).

According to the authors, several factors can influence the osseointegration process, such as the implants' microstructure, diameter, length, bone quality, quantity, and the patient's systemic conditions (8,9,25,28,12,35). For this reason, proper and individualized planning is crucial, given the vast diversity of conditions in different patients (12,30,31,36). An interdisciplinary approach to surgical planning is also necessary since the most diverse specialties contribute to a good diagnosis, planning, and execution (30).

In a study on short implants in clinical practice, the results were effective and with a high survival rate (15). As with other studies on patients who underwent surgery with short implants over 3 to 5 years, the authors reported a success rate of between 94% and 97% (13-15). These results suggest they are as successful as long implants (14). Also, short-term studies, ranging from 12 to 24 months, conclude implant stability and patient satisfaction (16,36), although one of these cases showed a small saucerization (36), vertical loss of up to 0.2mm does not affect the functionality or success of the implant (25).

Recent studies and research have shown that the numerous advantages of short implants stand out: low risk of neurosensitive injury, lower cost and discomfort, and the possibility of immediate loading (10-12). Evidence shows that immediate implantation helps to maintain the outline of the gingival anatomy and preserve the alveolar anatomy and bone ridges (11,35).

CONCLUSION

As an alternative in the rehabilitation of patients with edentulous and atrophic bone structures who cannot or, by choice, do not want more complex surgical treatments, implants classified as short (<10mm) and/or ultra-short (4mm), cone morse model, are the best option, according to the literature above review, achieving a higher rate of predictability in rehabilitation success. A large body of literature guarantees its benefits, but to ensure the success rate of these implants with immediate loading, careful prior reverse planning and follow-up are necessary. Thus, total rehabilitation of atrophic bone structures on short and ultra-short implants can be an effective treatment option, with a less invasive technique, minimal marginal bone loss, and a low implant failure rate in the short term. Though, studies with long-term observations are needed to establish this prognosis better.

The authors declare that there are no conflicts of interest.

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REFERENCES

1. Neto UGG, Bacelar SM de A. Implantes dentários com superfície tratada: Revisão de literatura. Braz J Implantol. 2019 Sep 15;1(4):69-83.
2. Brånemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg. 1969;3(2):81-100.
3. Scarano A, Bernardi S, Rastelli C, Mortellaro C, Vittorini P, Falisi G. Soft tissue augmentation by means of silicon expanders prior to bone volume increase: a case series. J Biol Regul Homeost Agents. 2019;33(6 Suppl 2):77-84.
4. Srinivasan M, Vazquez L, Rieder P, Moraguez O, Bernard JP, Belser UC. Survival rates of short (6 mm) micro-rough surface implants: a review of literature and meta-analysis. Clin Oral Implants Res. 2013 Feb 18;25(5):539-45.
5. Yalçın M, Can S, Akbas M, Dergin G, Garip H, Aydil B, *et al*. Retrospective Analysis of Zygomatic Implants for Maxillary Prosthetic Rehabilitation. Int. J. Oral Maxillofac. Implant. 2020, 35, 750–756.
6. Jung RE, Al-Nawas B, Araujo M, Avila-Ortiz G, Barter S, Brodala N, *et al*. Group 1 ITI Consensus Report: The influence of implant length and design and medications on

clinical and patient-reported outcomes. Clin Oral Implant Res. 2018;29(Suppl):69-77.
7. Frascaria M, Pietropaoli D, Casinelli M, Cattaneo R, Ortu E, Monaco A. Neutral zone recording in computer-guided implant prosthesis: A new digital neuromuscular approach. Clin Exp Dent Res. 2019;5(6):670-6.
8. Cicconetti A, Passaretti A, Rastelli C, Rastelli E, Falisi G. Innovations in oral and maxillofacial surgery: Biomimetics meets physiology. J Biol Regul Homeost Agents. 2019;33(5):1609-13.
9. Guillaume B. Dental implants: A review. Morphologie. 2016 Dec;100(331):189-98.
10. Silva IDD, Pavan ÂJ, Camarini ET, Gomes CR de G. A reabsorção óssea alveolar severa e a utilização de implantes curtos: Revisão de literatura. Revista Uningá. 2019 Jul 17;56(S5):43-53.
11. Pellizzer EP, Moraes SLD de, Santiago Junior JF, Almeida DA de F, Honório HM, Verri FR. Implantes curtos do tipo cone - Morse: Proporção coroaimplante. Rev Cir Traumatol Buco-Maxilo-Fac. 2013 Sep 1;13(3):79-86.
12. Costa ABS, Paiva JL de, Lucena T de A, Barbosa MES, Pereira TBF, Duarte TV de A, *et al*. O uso de implantes curtos para reabilitação de mandíbula atrófica: revisão de literatura. RSD. 2022 Nov 26;11(15):e559111537714.
13. Lages FS, Queiroz TP, Oliveira DWD, Margonar R, Rivera CP, Marcantonio E. Cinco anos de reabilitação total de mandíbula atrófica com implantes curtos em carga imediata – relato de caso. Full Dent Sci. 2016;8(29):82-5.
14. Manfro R, Bortoluzzi MC, Pratto LM, Fabris V, Cecconello R, Bitencourt AZ. Mandíbulas Edêntulas Severamente Reabsorvidas Tratadas com Implantes Curtos – Apresentação de 4 Casos Clínicos e Controle de 30 a 36 Meses. J Oral Investig. 2013 Jun 30;2(1):10-6.
15. Pauletto P, Ruales-Carrera E, Gonçalves T, Philippi A, Donos N, Mezzomo L. Fixed and Removable Full-Arch Restorations Supported by Short (≤ 8 mm) Dental Implants in the Mandible: A Systematic Review and Meta-Analysis. Int J Oral Max Impl. 2019 Jul;34(4):873-85.
16. Luca S, Tomazi, FHS, Rocha, MM, Conci RA, Griza GL. Prótese inferior do tipo protocolo sobre implantes curtos com carga imediata - relato de caso. Rev Odontologia (ATO). 2015 Fev;15(2):49-58.
17. Falisi G, Di Paolo C, Rastelli C, Franceschini C, Rastelli S, Gatto R, *et al*. Ultrashort Implants, Alternative Prosthetic Rehabilitation in Mandibular Atrophies in Fragile Subjects: A Retrospective Study. Healthcare (Basel). 2021 Feb 6;9(2):175.
18. Perelli M, Abundo R, Corrente G, Saccone C. Short (5 and 7 mm long) porous implants in the posterior atrophic maxilla: a 5-year report of a prospective single-cohort study. Eur J Oral Implantol. 2012;5(3):265-72.
19. Rossi F, Botticelli D, Cesaretti G, De Santis E, Storelli S, Lang NP. Use of short implants (6 mm) in a single-tooth replacement: a 5-year follow-up prospective randomized controlled multicenter clinical study. Clin Oral Implants Res. 2015 Feb 18;27(4):458-64.
20. Felice P, Checchi L, Barausse C, Pistilli R, Sammartino G, Masi I, *et al*. Posterior jaws rehabilitated with partial prostheses supported by 4.0 x 4.0 mm or by longer implants: One-year post-loading results from a multicenter randomised controlled trial. Eur J Oral Implantol. 2016;9(1):35-45.
21. Ewers R. The incisal foramen as a means of insertion for one of three ultra-short implants to support a prosthesis for a severely atrophic maxilla – A short-term report. Heliyon. 2018 Dec;4(12):e01034
22. Elias DM, Valerio CS, de Oliveira DD, Manzi FR, Zenóbio EG, Seraidarian PI. Evaluation of Different Heights of Prosthetic Crowns Supported by an Ultra-Short Implant Using Three-Dimensional Finite Element Analysis. The Int J Prosthodont. 2020;33(1):81-90.
23. Ferrantini Gonçalves de Almeida J, Gomes Silva M. Implantes curtos em região posterior de maxila: uma revisão narrativa da literatura. Pesquisas e Inovações em Odontologia: Produções Científicas Multidisciplinares no Século XXI. 2022 Aug 20;1:7-26
24. Pistilli R, Baurasse C, Gasparro R, Berti C, Felice P. Minimally Invasive Fixed Reabilitation of a Totally Edentulous Severely Atrophic Mandible with 4-mm Ultrashort Immediately Loaded Implants: A Case Report. Int J Periodontics Restorative Dent. 2020;40(4):549-59.
25. Amorim H, Gomes CE. Implantes curtos na região maxilomandibular posterior. J Implantol Health Sci. 2020 Nov 29;2(12):19-29.
26. Hadzik J, Krawiec M, Sławecki K, Kunert-Keil C, Dominiak M, Gedrange TA. Influência da relação coroa-implante no nível ósseo crestal e na estabilidade secundária do implante: estudo clínico de 36 meses. BioMed Pesquisa Internacional. 2018;2018:1-7.
27. Cruz RS, Lemos CAA, Batista VES, Oliveira HFF, Gomes JML, Pellizzer EP, *et al*. Short implants versus longer implants with maxillary sinus lift. A systematic review and meta-analysis. Braz Oral Res. 2018 Sep 13;32:e86.
28. Luiz R, Maia S. Implantes curtos. Braz J Implantol Health Sci. 2022 Feb 3;4(1):35-49.
29. Ewers R, Marincola M, Perpetuini P, Morina A, Bergamo ETP, Cheng YC, *et al*. Severely Atrophic Mandibles Restored With Fiber-Reinforced Composite Prostheses Supported by 5.0-mm Ultra-Short Implants Present High Survival Rates Up To Eight Years. J Oral Maxillofac Surg. 2022 Jan;80(1):81-92.
30. Dreossi GB, Landi BM, Campaner M, Shibayama R. Planejamento reverso em implantodontia - Revisão de literatura. Rev Odontol Arac. 2021;42(2):53-7.
31. Barros AC, Cardoso E, Barbosa M, Tenório MD, Barros J, Ribeiro MI. Planejamento reverso em implantodontia: revisão de literatura. BJHR. 2023 Jun 12;6(3):12339-46.
32. França SSM, Paraguassu EC. Carga imediata em prótese total implantosuportada: Revisão de literatura. Braz J Implantol Health Sci. 2022 Feb 3;4(1):14-34.
33. Wagner AA. Implantes curtos: tamanho, sobrevida e influência da proporção coroa-implante: revisão de literatura. J Multidiscip Dent. 2022 Sep 2;10(3):57-63.
34. Sedov Y, Mordanov O, Grigoriev S, Avanesov A, Khabiev K. The Placement of Four Short Implants and Full-Arch Early Loading in the Edentulous Patient Suffering from Severe Mandibular Alveolar Ridge Atrophy. Case Rep Dent. 2019 Oct 22;2019:1656243.

35. Trento CL, Moreschi E, Zamponi M, Zardeto Júnior R, Gottardo VD, Costa DG. Implantes cone morse com carga imediata: relato de caso. Odontologia Clínico-Científica. 2012 Jun 1;11(2):159-64.
36. Manfrinato L, Marchiolli CL, Oliveira ME de FS, De Souza FRB. Fatores cirúrgicos e o planejamento da reabilitação total com próteses implanto-suportada e carga imediata / Surgical factors and planning for total rehabilitation with implant-supported prosthesis and immediate load. Braz J Develop. 2021 Nov 22;7(11):106818-37.
37. Nunes V, Del'Arco A, Barbosa JV, Ocon T, Faverani LP, Paula A. Implantes dentários curtos na implantodontia moderna: revisão sistematizada. Arch Health Invest. 2019 Mar 11;7(11):477-81.