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# SUMMARY

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# EDITORIAL

We express our great honour in publishing the fiftieth edition of the Naval Dental Journal.

The number two of this commemorative edition coincides with a singular moment in the history of Naval Central Dentistry: obtaining the seal of Institution of Science and Technology. As an integral part of this successful and recognized trajectory, the Naval Dental Journal, an electronic scientific journal, constitutes an important scientific dissemination tool, having as one of its main commitments the link between the researcher and the dental surgeon. It is a publication channel for clinical studies and literature reviews, indexed in the most renowned national and international databases, occupying the honorable second position in the ranking of most accessed journals in the Brazilian Navy, with a monthly average of 1800 accesses. In this special edition we bring our readers two original articles, a case report and three literature reviews.

The first article evaluates the surface of tooth enamel using Scanning Electron Microscopy, after removing residual resin following the orthodontic bracket debonding procedure. The second original article is a cross-sectional study that evaluates the general health and oral hygiene profile of elderly patients treated at the Integrated Home Care Service of Hospital Naval Marcílio Dias.

The case report presents the surgical technique for creating a synthetic bone graft using CAD/CAM (computer aided design/computer aided manufacturing) technology, followed by the installation of osseointegrated implants and prosthetic rehabilitation in a bone defect in the mandible.

Finally, we present three literature review: one regarding the contribution of digital technology to the surgical technique of mini-implants insertion, one about Actinic Cheilitis ("Sailor's Lips") and the last one discuss the importance of methods for determining skeletal and dental ages in Orthodontics and Pediatric Dentistry.

Monthly, the Naval Central Dentistry provides assistance to around 15,000 users of the Navy Health System, with clinical approaches completely included in the concept of Evidence-Based Dentistry. This applied concept integrates scientific evidence with the vast clinical experience of more than 180 dental surgeons, with the aim of meeting the needs of users of the Navy Health System. Equipped with highly committed and qualified professionals, who have at their disposal the most modern technology in terms of diagnosis and therapy in 11 specialties of Dentistry, the Naval Central Dentistry is established as a highly promising environment for the development of Innovation in the Health area.

Looking forward to reaffirm its historical commitment to excellence in Dentistry, which from now on is also aligned with the firm purpose of promoting Science, Technology and Innovation, the Naval Central Dentistry brings benefits to our valued combatants, their families and Brazilian society.

TERESA CRISTINA PEREIRA DE OLIVEIRA
Commander
Editor-in-chief

ORIGINAL ARTICLE

# EVALUATION OF THE EFFECTS OF RESIDUAL RESIN REMOVAL AND POLISHING ON THE ENAMEL SURFACE AFTER BRACKETS DEBONDING

## *AVALIAÇÃO DOS EFEITOS DA REMOÇÃO DA RESINA RESIDUAL E DO POLIMENTO NA SUPERFÍCIE DO ESMALTE APÓS DESCOLAGEM DO BRAQUETE*

Carlos Eduardo de Oliveira Lima[1], Luíz Sérgio Carreiro[1], Paulo Eduardo Bággio[1], Pedro Marcelo Tondelli[1], Ricardo Takahashi[1], Ane Caroline Godoi da Silva[2]

## ABSTRACT

Considering the use of specific burs to remove residual resin after bracket debonding and the possibility of injuries to the dental enamel after using these burs, this study aimed to verify the variation in the enamel surface appearance in a qualitative way and evaluation with topographic images of the dental enamel. The use of Scanning Electron Microscopy (SEM) allowed to illustrate and evaluate the enamel surface after the final polishing phase using two methods: rubber cup or Robinson brush. Twenty-five human premolar teeth were obtained from extractions in patients who voluntarily sought the Oral Maxillofacial Surgery Residency at the Dental School from the State University of Londrina; the teeth were divided into four groups A, B, C and D containing 6 teeth each according to the burs used to remove the remaining adhesive and the chosen polishing, in addition to one tooth as a "control". Dental enamel surface roughness was evaluated after resin removal and enamel surface after polishing with the two methods presented. The results showed that by observation and inspection, the burs removed residual resin from all teeth, however, caused scratches and grooves as evidenced in the SEM images. Based on the results, there was no statistical difference between the polishing methods, and both were important for the reduction of abrasive marks and provided a smoother enamel surface.

**Keywords:** Dental enamel, Dental debonding, Orthodontic brackets, Scanning electron microscopy, Dental polishing.

## RESUMO

Considerando o uso de brocas para remoção da resina residual após descolagem do braquete e a possibilidade de injúrias à superfície do esmalte após o uso dessas brocas, este trabalho teve como objetivo realizar um estudo experimental para avaliar a variação do aspecto superficial do esmalte de forma qualitativa, por meio da avaliação com imagens topográficas do esmalte dentário, utilizando-se a Microscopia Eletrônica de Varredura (MEV), a qual permitiu ilustrar e avaliar a superfície do esmalte após a fase de polimento final, realizada por dois métodos: taça de borracha ou escova Robinson. Foram utilizados 25 dentes pré-molares humanos, obtidos a partir de exodontias em pacientes que procuraram voluntariamente o curso de Residência em Cirurgia da Clínica Odontológica Universitária da Universidade Estadual de Londrina. Os dentes foram divididos em quatro grupos: A, B, C e D, contendo 6 dentes cada, de acordo com as brocas utilizadas para a remoção do remanescente adesivo e o polimento escolhido, além de um dente como "controle". Foi avaliada a rugosidade superficial do esmalte após a remoção da resina e a superfície do esmalte após o polimento com as duas opções apresentadas. Os resultados mostraram que, por observação e inspeção, as brocas removeram a resina residual de todos os dentes, porém, causaram riscos e ranhuras, como evidenciado nas imagens em MEV. Concluiu-se que não houve diferença estatística entre os métodos de polimento e que ambos foram importantes para a redução das marcas abrasivas, proporcionando uma superfície mais lisa do esmalte.

**Palavras-chave:** Esmalte dentário, Descolagem dentária, Braquetes ortodônticos, Microscopia eletrônica de varredura, Polimento dentário.

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## INTRODUCTION

The search for an efficient and safe method for removing residual resin after debonding orthodontic devices has resulted, over time, in a wide variety of procedures. Nevertheless, even when used correctly, they can cause grooves and irregularities on the enamel surface (1), making it difficult to obtain good results without iatrogenic damage (2). The rough surface makes proper cleaning difficult, invites the deposition and retention of biofilm, and the formation of stains (2).

In the orthodontic routine, aiming to minimize the grooves caused by the burs and obtain a smoother and more homogeneous surface closer to the surface of the initial enamel, after removing the remaining resin, materials are used for the final polishing. This is an essential step for orthodontic post-treatment, enabling the recovery of aggressions to the enamel surface, avoiding the accumulation of biofilm, minimizing the chances of stains and/or caries lesions. In addition, the careful removal of remaining resin provides a more favorable aesthetics, contributing to a good oral health and, consequently, an improvement in the patient's quality of life. Although final polishing is an essential step to reduce marks produced by instruments, there is still no consensus regarding the best method for carrying it out (3, 4).

In the present study, the importance of orthodontic bracket removal procedures after completion of treatment was considered, followed by the removal of residual resin that was used to bond these accessories and the final polishing of the enamel surface.

This research aimed to evaluate the enamel surface after removing the residual resin with burs, with the aid of the Scanning Electronic Microscope (SEM), as well as the use of two types of polishing, one using a Robinson brush and pumice paste, and another using a rubber cup with pumice paste.

## METHODS

An experimental/laboratory study was carried out with the purpose of evaluating the use of two types of enamel polishing, after removing the orthodontic bracket and residual resin with two types of burs, one with high speed and the other with low speed. Human premolar teeth were used, extracted for orthodontic indications, from patients who voluntarily sought the Residency in Oral and Maxillofacial Surgery and Traumatology at the Dental School of the State University of Londrina (UEL), Brazil. The teeth were extracted without the need for tooth sectioning and kept in saline solution for a maximum period of 3 months.

As exclusion criteria, teeth with an origin other than the UEL, teeth with previous restorations, teeth extracted and stored outside the maximum period of 3 months or sectioned at the time of extraction, were discarded. The sample consisted of 25 healthy human premolars, 1 tooth being "Control" and the other 24 teeth divided into Group A, Group B, Group C and Group D, which had brackets glued and removed after 1 month and the residual resin removed with a bur. Except for the "Control" tooth, all specimens had metal brackets bonded with Transbond XT resin (3M Unitek ®, Monrovia, CA, USA) according to the manufacturer's instructions. The Groups were divided as follows: Group A: A1, A2: a high speed bur was used to remove residual resin; A3, A4, A5 and A6: high speed bur used to remove residual resin, followed by polishing with a Robinson brush and pumice stone; Group B: B1, B2: a high speed bur was used to remove residual resin; B3, B4, B5 and B6: bur at high speed used to remove residual resin, followed by polishing with a rubber cup and pumice stone; Group C: C1, C2: a low speed bur was used to remove residual resin; C3, C4, C5 and C6: bur at low speed used to remove residual resin, followed by polishing with a Robinson brush and pumice stone; Group D: D1, D2: a low speed bur was used to remove residual resin; D3, D4, D5 and D6: bur at low speed used to remove residual resin, followed by polishing with a rubber cup and pumice stone.

In preparation for bonding, all specimens underwent prophylaxis. The enamel was conditioned with 37% phosphoric acid (Magic Acid Vigodent®, Rio de Janeiro, RJ, Brazil) for 20 seconds, washed with a water/air spray, dried in oil-free air, until it reached a milky-white color. Then, the adhesive was applied with a brush and light-cured for 20 seconds. Transbond XT resin was dispensed onto the bracket base using spatula 1 (Duflex ®, Rio de Janeiro, RJ, Brazil). The bracket was positioned on the tooth surface using orthodontic forceps (Morelli ®, Sorocaba, SP, Brazil) and pressed firmly, allowing the resin to penetrate the mesh. The excess resin around the base of the bracket was removed with an exploration probe (Duflex ®, Rio de Janeiro, RJ, Brazil) and light-cured for 40 seconds, 10 seconds on each side using the Optilight Max LED curing light (Gnatus ®, Ribeirão Preto , SP, Brazil) in continuous light intensity mode and at a power of 1200 mW\cm$^2$. Subsequently, the samples were stored in a humid environment for a week,

until the brackets were removed. Regarding the removal of the brackets, to transfer less amount of stress to the enamel and the adhesive layer, applied forces were used on the outer wings of the brackets using Straight How pliers (Starlet ®, São Paulo, SP, Brazil), through pressure on the fins, causing deformation of the base and consequent removal. The samples predominantly showed fractures at the bracket/adhesive interface, with the resin adhering to the tooth surface.

Samples with similar amounts of residual resin had this material removed with burs by a single professional, a specialist in Orthodontics, using a high speed handpiece and micromotor (low speed) according to the bur used, with the aid of a dental reflector. The high speed multi-blade with 18 blades bur, from the Angelus Prisma Dental (Reference Code 710359) and the low speed zirconia multi-blade bur, from the Morelli (Reference Code 75.03.001) were used. The bur was positioned parallel to the long axis of the teeth and horizontal, precise, one-way movements were performed on the resin. The pressure was carefully applied to the handpiece during cuts to maintain uniformity. The evaluation of the removal of residual resin was carried out by visual and macroscopic observation, until total removal of the remnants, with the aid of a dental reflector and a magnifying glass, in addition to the active tip of an exploration probe.

Regarding polishing, a Robinson brush was used, made with ultra-flexible nylon bristles (American Burrs, Palhoça, SC, Brazil) or a flexible and soft latex rubber cup (American Burrs, Palhoça, SC, Brazil); In both protocols, polishing was done with the aid of an extra-fine pumice stone (SS White, São Cristovão, RJ, Brazil) and water at low speed for 15 seconds and then washed with a jet of water for 20 seconds.

The research was mainly based on the evaluation of all phases using the Scanning Electron Microscope (SEM), 400x magnification, in search of the final parameters of each phase. The experimental part was developed at the Electronic Microscopy and Microanalysis Laboratory (LMEM) at UEL. In the preparation process, the samples were cleaned and dried, and the material was fixed on metal bases containing double-sided carbon adhesive tape. Then, they received a layer of gold approximately 20 nm thick, as the gold on the surface allows us to obtain high-resolution images. In this process we used a sputter coater, Bal-Tec brand, SCD 050. After that, the material was analyzed using a Philips Scanning Electron Microscope (SEM), Quanta 200; using a voltage of 20 kV and a working distance (WD) of 10 mm. The images were digitized and subsequently observed and compared to evaluate the appearance of the enamel surface, considering similar magnifications.

To evaluate roughness, the Enamel Roughness Index (ERI) was proposed, which evaluates the enamel surface in terms of smoothness conditions (Chart 1). To apply this index, the photographed area was subdivided into 100 equal parts, using a grid created on top of the photograph using the Power Point (Microsoft Corporation, Seattle, USA). After this, the number of damaged areas during the process of removing the orthodontic bracket and residual composite was evaluated. The evaluation was carried out directly on the computer screen, in a dark room to better visualize the enamel surface. Once the damaged areas were counted, the specimens had their appropriate score determined and were classified according to Table 1.

Therefore, the higher the group average, the greater the damage caused to the enamel after removal or removal plus polishing. The assessment was carried out in three different periods by the same individual, previously calibrated. The average found in the three assessments was noted and classified following the ERI. This index has greater reliability when compared to the surface roughness index (SRI), proposed by Howell and Weekes (5), since the ERI has a greater number of scores.

## CHART 1 – ENAMEL ROUGHNESS INDEX (ERI).

| | |
|---|---|
| **1** | up to 10% of the scratched surface |
| **2** | up to 20% of the scratched surface |
| **3** | up to 30% of the scratched surface |
| **4** | up to 40% of the scratched surface |
| **5** | up to 50% of the scratched surface |
| **6** | up to 60% of the scratched surface |
| **7** | up to 70% of the scratched surface |
| **8** | up to 80% of the scratched surface |
| **9** | up to 90% of the scratched surface |
| **10** | More than 90% of the scratched surface |

The research was approved by the Research Ethics Committee of the State University of Londrina – UEL, through protocol number CAAE 17075519.5.0000.5231.

The data obtained were analyzed using the R package version 1.2.2 software and considered the weights presented by the study's sampling design. Considering the procedures, the Shapiro-Wilk analysis of variance, Barlett analysis for homogeneity of variances and the Tukey test for multiple comparisons were used.

## RESULTS

Scanning Electron Microscopy (SEM) images, with 400x magnification, after using burs to remove residual resin, showed enamel surfaces with different levels of irregularities and images showing scratches or grooves. There were no significant differences between the 2 different methods of final enamel polishing tested. Despite the important and efficient result of the polishing, observed in the SEM images, we can state that no enamel surface was restored to its original appearance.

All protocols tested efficiently removed the remaining resin, considering both by visual assessment, with the aid of the dental reflector and the active part of the exploration probe, and by SEM. However, they led to considerable changes in the topography of the enamel with the appearance of grooves and small erosions (scratches) on the surface (Figure 2: A1 and A2; Figure 3: B1 and B2; Figure 4: C1 and C2; Figure 5: D1 and D2). The debonding procedures, followed by removal of the remaining resin with the two types of burs (Tungsten burs with 18 blades at high speed, brand Angelus prism dental and Tungsten zirconia burs at low speed, Morelli), resulted in a slightly rough surface , with irregularities on the enamel surface at different levels, as shown by the averages of the ERI, with 7.5 for Group A (Tungsten carbide burs with 18 blades at high speed), 4.5 for Group B (Tungsten carbide burs with 18 blades at high speed), 8.5 for Group C (zirconia Tungsten burs at low speed) and 5.0 for Group D (zirconia Tungsten burs at low speed) (Table 1).

For Group A, in which resin removal was carried out with a Tungsten carbide burs with 18 blades at high speed, and polishing with a Robinson brush and pumice stone, the photomicrographs revealed a great number of erosions and scratches (Figure 2: A1 and A2) compared to the Control tooth (Figure 1). After polishing with pumice, well-polished enamel surfaces were observed, although some marks or depressions were still present. (Figure 2: A3, A4, A5 and A6).

For Group B, with the resin removal performed using a Tungsten carbide burs with 18 blades at high speed, followed by polishing with a rubber cup and pumice stone, moderate striations on the enamel surface were observed after removal of the residual resin (Figure 3: B1 and B2). The use of pumice stone was efficient in polishing the enamel, softening the abrasive marks, though it was not able to remove more obvious grooves (Figure 3: B3, B4, B5 and B6).

In the protocol used in Group C, zirconia Tungsten burr was used at low speed, which efficiently removed the remaining resin, generating light grooves and striations on the tooth surface (Figure 4: C1 and C2). Subsequently, the use of a Robinson brush and pumice stone resulted in more efficient enamel polishing (Figure 4: C3, C4, C5 and C6), approaching the topography of the enamel of the control tooth.

For Group D, erosions and scratches caused by the zirconia Tungsten carbide burs at low speed (Figure 5: D1 and D2) were smoothed after polishing with a rubber cup and pumice stone, resulting in a smoother enamel surface, but with some depressions (Figure 5: D3, D4, D5 and D6), observed microscopically.

In general, the zirconia Tungsten burs at low speed were slightly more aggressive than those at high speed, and the polishing phase with pumice paste showed a positive influence on surface recovery of the enamel. This is confirmed by observing the photomicrographs that, in the images of phases “1 and 2”, can be seen a blunt action of an object (bur), which caused grooves and small erosions on the treated surface. In the photos of phases “3, 4, 5 and 6”, there is a recovery through polishing, which left the surface smoother, but below the image of the control tooth, as shown by the ERI averages, with 1.75 for Group A (multi-blade burs with 18 blades at high speed to remove resin, followed by polishing with a Robinson brush and pumice stone), 1.5 for Group B (multi-blade burs with 18 blades at high speed to remove the resin, followed by polishing with a rubber cup and pumice stone), 1.0 for Group C (zirconia Tungsten burs at low speed to remove the resin, followed by polishing with a Robinson brush and pumice stone), and 2.25 for Group D (zirconia Tungsten burs at low speed to remove the resin, followed by polishing with a rubber cup and pumice stone) (Table 1).

After carrying out the simple analysis of variance and considering the procedures, the assumptions of normality of residues (Shapiro-Wilk, p-value 0.0647) and homogeneity of variances (Barlett, p-value 0.6932) were satisfied for the data transformed by the logarithmic function. As the analysis of variance was significant (p-value 0.000203), Tukey’s multiple comparison test was performed considering a significance level of 5% and found that the groups with polishing did not differ from each other but differed significantly of all groups of teeth that were not polished. Besides, the groups polished with the rubber cup do not differ from the groups polished with the Robinson brush.

## TABLE 1 – SCORE VALUES ASSIGNED TO EACH TOOTH FOR THE ENAMEL ROUGHNESS INDEX (ERI).

| ERI | 1 | 2 | Mean (1 / 2) | 3 | 4 | 5 | 6 | Mean (3 / 4 / 5 / 6) |
|---|---|---|---|---|---|---|---|---|
| **A** | 8 | 7 | **7,5** | 2 | 1 | 1 | 3 | **1,75** |
| **B** | 6 | 3 | **4,5** | 2 | 1 | 2 | 1 | **1,50** |
| **C** | 8 | 9 | **8,5** | 1 | 1 | 1 | 1 | **1,00** |
| **D** | 6 | 4 | **5,0** | 3 | 1 | 2 | 3 | **2,25** |
| **Control Tooth** | | | **Score** | | **Mean (C)** | | | |
| **"C"** | | | **1** | | **1** | | | |

**A1, A2:** *High Speed to remove residual resin;* **A3, A4, A5 and A6***: High Speed to remove residual resin + Robinson brush with pumice stone;*
**B1, B2***: High Speed to remove residual resin;* **B3, B4, B5 and B6***: High Speed to remove residual resin + rubber cup with pumice stone;*
**C1, C2***: Low Speed to remove residual resin;* **C3, C4, C5 and C6***: Low Speed to remove residual resin + Robinson brush with pumice stone;*
**D1, D2***: Low Speed to remove residual resin;* **D3, D4, D5 and D6:** *Low Speed to remove residual resin + rubber cup with pumice stone.*

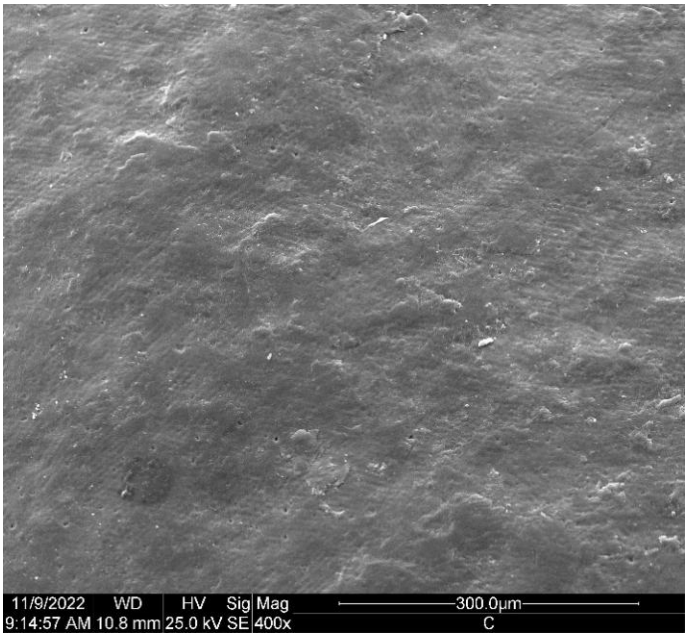


**Figure 1:** *Control tooth (C). SEM 400x.*

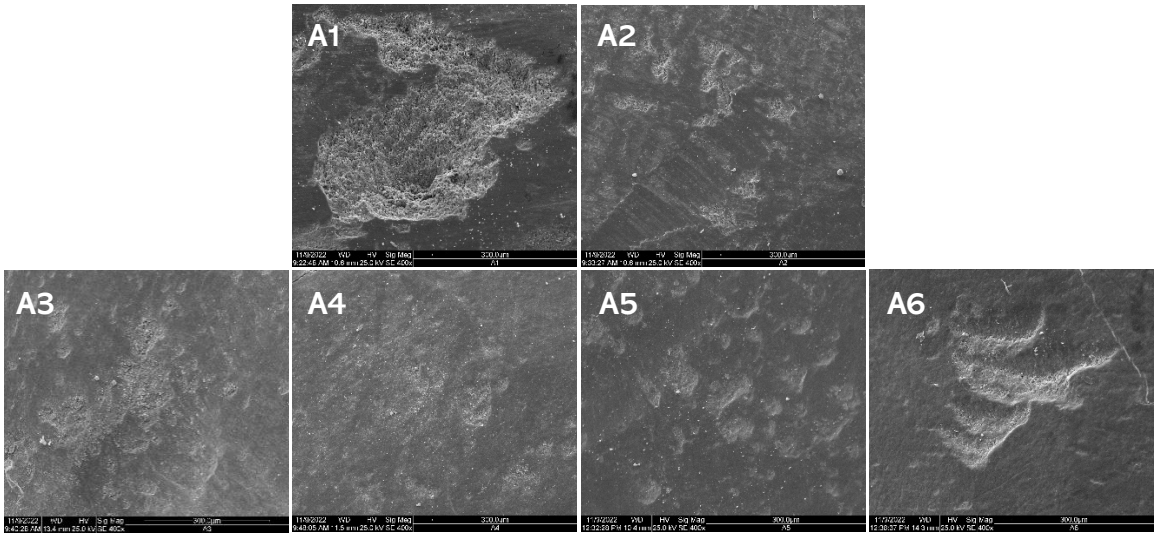


**Figure 2 – Group A. A1, A2:** *High Speed to remove residual resin;* **A3, A4, A5 and A6***: High Speed to remove residual resin + Robinson brush with pumice stone. SEM 400x.*

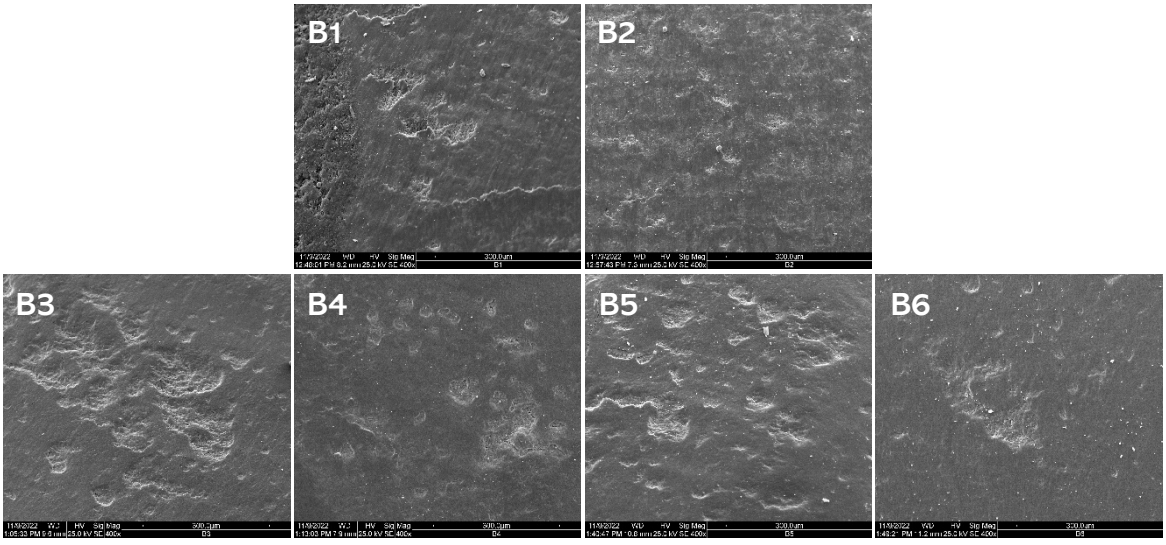


**Figure 3 – Group B. B1, B2:** *High Speed to remove residual resin;* **B3, B4, B5 and B6***: High Speed to remove residual resin + rubber cup with pumice stone. SEM 400x*

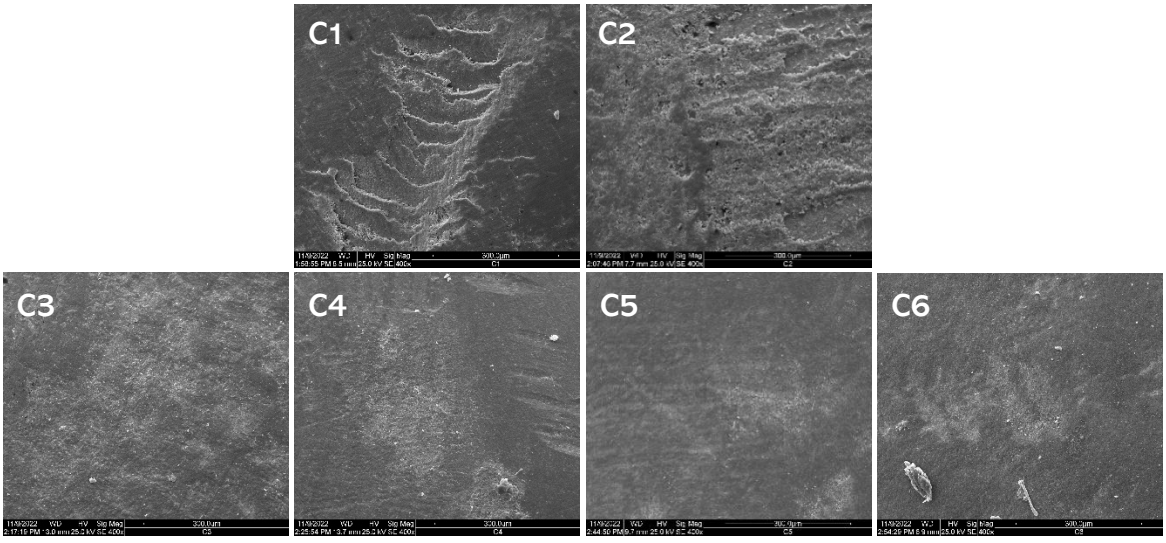


**Figure 4 – Group C. C1, C2:** *Low Speed to remove residual resin;* **C3, C4, C5 and C6***: Low Speed to remove residual resin + Robinson brush with pumice stone. SEM 400x.*

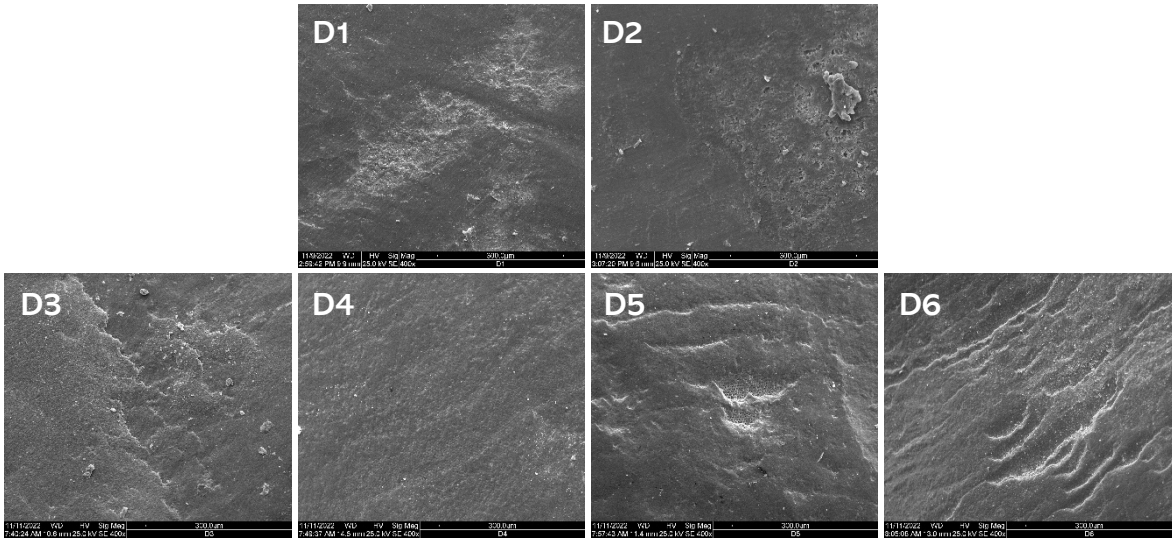


**Figure 5 – Group D. D1, D2:** *Low Speed to remove residual resin;* **D3, D4, D5 and D6***: Low Speed to remove residual resin + rubber cup with pumice stone. SEM 400x.*

## DISCUSSION

One of the biggest challenges after orthodontic treatment is the precise removal of the adhesive residue, aiming to avoid not only irreversible iatrogenic injuries, such as rough surfaces, vertical cracks, pulp necrosis, loss of the external surface rich in fluoride, but also the presence of residues of adhesive in the adhesion area (6).

The protocols used to remove the brackets and residual adhesive caused irregularities and grooves in the enamel and severe damage to the enamel surface, and polishing was unable to reduce the damage (1-4, 6-15).

The removal of remnants resins from the tooth surface with the use of rotary instruments after orthodontic treatment can eventually cause damage to the enamel (2, 6, 9, 11, 13, 15) and loss of surface structure with exposure of the endings of the enamel prism to the oral environment, accumulation of biofilm and pigments in microcracks, which can cause a decrease in surface resistance to organic acids. Eventually, these changes make the enamel more susceptible to demineralization and results in stains at the resin/enamel interface (1, 2, 6, 9, 12, 14, 16-18), which may cause irreversible damage to the enamel (3, 8, 10, 19). Thus, it is necessary to consider the importance of trying, after removing the residual resin from the enamel, to restore the surface as close as possible to the pre-treatment conditions (9), even though no enamel surface has been restored to its original appearance (19). The hypothesis that the use of burs to remove residual resin damages and alters the enamel surface was confirmed by this study.

There are several techniques for removing residual resin, such as diamond burs, polishing tips, and tungsten carbide multi-blade burs at low and high speed (16). They can still be removed with pliers, scrapers, abrasive discs, stones, or ultrasonic instruments; irregularities caused by these rotating instruments result in greater roughness of the enamel surface (1).

Although there was no consensus in the literature, the most common way to remove adhesive residues after orthodontic removal is using tungsten carbide burs (1), and this option has been suggested by several authors (7, 16, 19-25).

According to Ferreira *et al.* (19), the debonding procedure, followed by removal of the remaining resin with a tungsten carbide multi-blade burs resulted in a slightly rough surface, with different levels of irregularities on the enamel surface. Conical tungsten carbide burs with 12 and 30 blades at high speed proved to be fast and efficient in removing residual resin (26). In the present study, a Tungsten carbide burr with 18 blades was used at high speed and a zirconia Tungsten burr at low speed; In general, burs at low speed were slightly more aggressive than those at high speed, without statistical significance though. On the other hand, some studies have shown that burs used at low speed obtained better results, causing less damage (1, 3, 27).

Instead of the tungsten carbide burr, there are reports in the literature that it is preferred to other materials, such as Arkansas stone, which produces thin, shallow scars with a more homogeneous morphological appearance (13), aluminum oxide discs (12), residual adhesive remover, which caused less damage to the enamel surface (28), fiberglass burs, which scratch the surface less, being a good option for finishing and post-removal polishing of orthodontic brackets (29, 30), discs Sof-Lex, which are presented as a more economical option (31), and the carbide finishing burs, which removes residual adhesive resin gently and effectively after detaching the bracket (32). There are still indications for the diamond bur, which removed the resin in approximately half the time compared to the eight-blade burr (8), and the Stainbuster burr, which created a smoother enamel surface, close to natural enamel (14).

The difference in cutting efficiency and residual resin removal can be determined by the rotation speed of the burr (29). Some authors (33, 34) preferred burs used at low speed, which would be safer.

Polishing after removing the orthodontic bracket is necessary and essential to obtain a surface with less surface roughness (31) and recover the enamel surface, leaving it smoother and brighter (3, 7, 9, 16, 22, 34, 35). According to some authors (10, 19, 20), polishing methods were unable to restore the original enamel surface after bonding and detaching the brackets and removing the residual resin. However, after removing the adhesive residue, all teeth had acceptable and satisfactory enamel surfaces (1).

The literature has little information about the effect of different systems for polishing enamel after removing orthodontic brackets, therefore, more studies are needed to test these finishing techniques (26), as well as finding increasingly more effective methods with less damage to the enamel surface (21).

In a comparative study, the enamel polishing was compared with aluminum oxide paste and water slurry of fine pumice (22). Although no

statistically significant differences were found in polishing between the groups, SEM analysis showed a smoother enamel surface when polishing is carried out with aluminum oxide paste compared to pumice stone, in addition to visually presenting a brighter surface. According to Macieski *et al.* (3), final polishing with polishing paste or pumice stone is considered an essential step to reduce the abrasive marks produced by the instruments during the removal of the remaining adhesive and is essential to obtain smoother enamel surfaces.

In the current study, the specimens were polished with pumice, using a Robinson brush or rubber cup for 15 seconds. After polishing, there was an improvement or recovery in the enamel surface, previously damaged with grooves and scratches caused by burs, as can be seen in Table 1, which shows the individual scores per specimen and phase respectively, both after use of burs, such as recovery after polishing; corroborating the literature, stating that polishing with pumice promotes a smoother and more homogeneous surface and reduces roughness after using burs, becoming an essential step after orthodontic treatment (2, 3, 6, 7, 9, 11, 15, 20, 23, 36).

However, one study showed that final polishing with pumice was not sufficient to restore the enamel surface to the pre-treatment level (33). Furthermore, it was also shown that polishing with aluminum oxide paste, when compared to pumice stone, presents better results (22).

Vieira *et al.* (20) performed polishing with a rubber cup, pumice stone and water for 10 and 30 seconds, and the results provided by SEM analysis showed that the pumice stone is necessary after removing the brackets and the procedures did not provide a surface equal to healthy enamel. On the other hand, Pignata *et al.* (11) used pumice stone, water, and a rubber cup for 30 seconds to polish the enamel and showed better results with increasing enamel polishing time, since the damage was minimized, reducing scratches and grooves, leaving only the deepest ones. Contrastingly, Cardoso *et al.* (6) polished with a pumice stone (SS White) and a rubber cup (Microdont) for 10 seconds and restored the initial conditions of the enamel. For Tavares (9) and Gregório *et al.* (36), polishing with a rubber cup, pumice stone and water was efficient, as this process reduced the roughness values of all groups evaluated, as well as Fonseca, Pinheiro and Medeiros (16), who recommended polishing the enamel surface with rubber cups to increase smoothness and shine similar to natural enamel.

Janiszewska-Olszowska *et al.* (23) recommended the use of pumice paste for polishing and contraindicated Arkansas stones, green stones, diamond burs and lasers for removing residual adhesive. Other options for polishing the enamel surface were also mentioned, after removing the residual resin, such as finishing with graduated polishing discs or ceramic burs, which cause less damage to the enamel surface (7); the use of Enhance with polishing pastes (21); rubber cup and polishing paste (1); silicate paste and rubber cup (32); PoGo micro polisher (37); Sox-Flex discs (31) and the Enhance finishing and polishing kit followed by the use of a Prisma Gloss polishing cup and paste (38).

When comparing polishing at high and low speed, it was observed that polishing at high speed generated a rougher surface with irregularities; the best result was obtained with the use of a rubber cup at low rotation and with refrigeration, which resulted in an enamel surface with fewer scratches and grooves, exhibiting a shiny and smooth surface (19). In this research, it was observed that the polishing phase proved to be important and efficient for the recovery of the enamel surface, and that this efficiency occurred both with the use of a Robinson brush plus pumice stone and with the use of a rubber cup with pumice stone, even though, it does not restore the initial condition of the enamel.

Removing resin residue from the tooth surface after detaching orthodontic accessories, without iatrogenic damage, is difficult to achieve, but it is an essential step to eliminate biofilm retention and restore the aesthetic surface of the tooth (2, 12, 14, 15, 18). Some authors have suggested new studies to find increasingly effective methods that cause less damage to the enamel surface, as restoring enamel to its original morphology is still a challenge (14, 19, 21).

## CONCLUSION

Based on the studies and results found, the types of burs used in this evaluation were effective and removed the residual resin after debonding the bracket but caused micro abrasions and changes to the enamel surface. There was no statistically significant difference between polishing with a Robinson brush and pumice stone, when compared to polishing with a rubber cup and pumice stone, and observation of the images showed that, in most cases, polishing was effective in reduction of the surface roughness of the enamel, providing a smoother and more polished enamel surface, below the image of the control tooth though.

The authors declare that there is no conflict of interest.

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ORIGINAL ARTICLE

# ELDERLY PEOPLE LIVING AT HOME: GENERAL HEALTH X ORAL HYGIENE

## *IDOSOS DOMICILIADOS: SAÚDE GERAL X HIGIENE BUCAL*

Patrícia Alves Scheid Jordan[1], Daniele Pereira de Mello de Oliveira[2], Marcela Mendes Medeiros Michelon[1], Teresa Cristina Pereira de Oliveira[1]

## ABSTRACT

The Integrated Home Assistance Service (IHAS) was created to provide integral home care for elderly people who are unable to go to the health care units of the Brazilian Navy. A cross-sectional, quantitative, and descriptive study was carried out to evaluate the general health and dental hygiene profile of these patients. The study included elderly people aged 60 years or older who were assisted between February 2017 and December 2022. Most of them were long-lived, with a mean age of 82.52 (±8.66) years, women (63.52%) and totally dependent on performing basic activities of daily living (88.9%). The most common diagnosis among them was dementia syndrome, accounting for 44.3% of cases. Additionally, a large portion of the elderly had associated comorbidities (71.9%), with Systemic Arterial Hypertension (59.2%) and Diabetes Mellitus (28.9%) as the most recurrent conditions. The study found a high prevalence of elderly with unsatisfactory (34.7%) or irregular (57.2%) oral hygiene. Nevertheless, there was no significant association between dental hygiene and comorbidities or the degree of dependence. Therefore, it is imperative that elderly people living at home receive guidance and undergo meticulous and ongoing monitoring, in conjunction with their caregivers to promote improvements in the oral hygiene of these patients.

**Keywords:** Aged, Elderly Health, Health Services for the Aged, Home Care Services, Comprehensive Health Care, Dental Care for Aged.

## RESUMO

O Serviço Integrado da Assistência Domiciliar (IHAS) foi criado a fim de prestar atendimento integral domiciliar a idosos que apresentam incapacidade de se locomover para as unidades de atendimento de saúde da Marinha do Brasil (MB). Com a finalidade de avaliar o perfil de saúde geral e de higiene dental desses pacientes, foi realizado um estudo transversal, quantitativo e descritivo, no qual foram incluídos idosos com 60 anos ou mais, assistidos entre fevereiro de 2017 a dezembro de 2022. Pode-se observar que a maioria dos idosos eram longevos, com média de idade de 82,52 anos (±8,66), mulheres (63,52%) e possuíam dependência total para realizar atividades básicas de vida diária (88,9%). Conclui-se que a síndrome demencial foi o diagnóstico principal mais encontrado (44,3%), a maioria possuía comorbidade associada (71,9%), sendo a Hipertensão Arterial Sistêmica (59,2%) e o Diabetes Mellitus (28,9%) as mais recorrentes. Foi encontrada uma elevada prevalência de idosos domiciliados com higiene bucal insatisfatória (34,7%) ou irregular (57,2%). No entanto, não houve associação entre higiene dental, comorbidades e grau de dependência. Assim sendo, é imprescindível que os idosos domiciliados recebam orientações e sejam submetidos a um acompanhamento rigoroso e constante, juntamente com seus cuidadores, a fim de promover a melhoria da higiene oral desses pacientes.

**Palavras-chave:** Idoso, Saúde do Idoso, Assistência a Idosos, Assistência Domiciliar, Atenção à Saúde do Idoso, Assistência Odontológica para Idosos.

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## INTRODUCTION

According to data provided by the Brazilian Institute of Geography and Statistics (IBGE), the Brazilian population over 60 years of age corresponded to 5.1% in the 1970s (1). This percentage doubled in 2021 (10.15%), and the number of people aged 65 or over is expected to reach 25.17% of the population by 2058 (2).

This exponential increase in the elderly population generates a significant change in the predominant diseases, varying from infectious and parasitic diseases (predominant in the young population) to chronic and degenerative diseases, thus requiring a complete change in the health care network (3).

Chronic and degenerative diseases can result in a general systemic imbalance in the elderly, which can progress to a decline in functional and cognitive capacity, resulting in a high degree of dependence and, consequently, a condition of bed restriction (4). These patients require greater care due to their high level of frailty, in addition to presenting an increased risk factor for complications and health problems, such as the development of pressure injuries, worsening respiratory conditions, anxiety, infections, social isolation and depression (5). As a result of complications, elderly people end up having precarious oral conditions (6). Oliveira *et al.* identified dependence on third parties for oral care, not guaranteeing a consistent method of oral hygiene (6). Thus, the general health situation of bedridden patients also becomes more delicate due to the barriers of physical limitations, cognitive losses, dependence on other people, as well as less access to dental services (7).

Faced with the population growth of elderly people, the need for different demands and in compliance with the Statute of the Elderly and the National Policy on the Elderly, the Brazilian Navy (BN) created, in 2009, the Integrated Home Assistance Service (IHAS). Since then, around 1500 patients have benefited from this service, however there is no analysis of the patient profile for better action planning. This study seeks to elucidate the general health and oral hygiene profile of this population and verify whether there is any association between the degree of dependence, number of comorbidities and oral hygiene.

## METHODS

This is a cross-sectional, quantitative, and descriptive study carried out in a home care service in BN. Elderly people aged 60 or over, of both sexes, assisted by the IHAS dental team between February 2017 and December 2022 were included in the study.

IHAS is linked to the Geriatrics clinic at Hospital Naval Marcílio Dias (HNMD) and operates in the city of Rio de Janeiro, Brazil, providing home care to elderly people who are unable to travel to BN health care units.

The IHAS multidisciplinary team is made up of doctors, nurses and nursing technicians, a social worker, dentist, psychologist, and nutritionist. The team works together to plan the individual therapeutic plan and supervise home care provided by accredited companies.

Many patients have cognitive or communication impairments since entering the service. Therefore, to participate in IHAS, the patient needs to have the support of a responsible caregiver, who has their guardianship. The documentation is checked at the first consultation with the social worker, before the patient is included in the program.

To carry out this study, the medical records of all 603 elderly patients evaluated by the Dentistry team during the period considered in this study were consulted. All data collection from medical records and oral hygiene examinations were carried out by a dental surgeon, a member of the IHAS team. The data refer to the patients' first assessment/ consultation when entered into the program.

The information collected in the service's database refers to the patient's sex, age, degree of dependence according to the Katz scale, diseases reported as the main diagnosis and the comorbidities present in the patients. This data appears in the medical record and refers to the information filled out by the team's professionals when carrying out the first assessment of the patient when admitted to the IHAS.

Patients received for treatment at IHAS invariably present some degree of functional impairment. This degree of dependence is measured by the Katz scale, which assesses the individual's ability to independently perform the six activities considered Basic Activities of Daily Living (BADL): personal hygiene or grooming, dressing, toileting, transferring or ambulating, and eating. For each activity carried out independently, one point is awarded, and the result can vary between independent (6 points), partially dependent (3 to 5 points) and totally dependent (≤2 points). Since the patients are included in the service depending on their level of functional impairment,

the participants of the present stud have partial or total dependence on BADL.

For the initial dental hygiene examination, personal protective equipment (mask, glove, coat, and cap), artificial light, dental mirror, and exploration probe nº 5 were used. Oral hygiene was assessed at the first dental appointment, observing the presence of food residues and other dirties that can be cleaned with adequate hygiene. The effectiveness of oral hygiene was classified according to the following parameters: when in the patient who had a large amount of food residue on the teeth and tongue, hygiene was considered unsatisfactory; the patient who had a small amount of food residue on his teeth and tongue had his hygiene considered regular; and the patient who did not have food residues on his teeth and tongue, had good hygiene.

The data were tabulated and analyzed descriptively. The chi-square test was used to evaluate a possible association between oral hygiene, number of comorbidities and degree of dependence. The significance level used was 0.05, and all data were evaluated using IBM SPSS 20.0 statistical software.

The study was submitted to the Ethics and Research Committee of Hospital Marcílio Dias (CEP-HNMD) and approved with substantiated opinion number 5994432.

## RESULTS

Data collection took place through 603 medical records of elderly people assisted by IHAS. The profile of users assisted by IHAS is presented in Table 1. Most of elderly patients assisted by IHAS during the study period were female (63.52%) and their ages ranged from 60 to 102 years, with an average age of 82.52 (+8.66) years.

Most of these elderly people (88.9%) were completely dependent to carry out BADL, necessarily depending on a caregiver.

### TABLE 1 – PROFILE OF USERS ASSISTED BY IHAS.

| Variable | *n* | % |
|---|---|---|
| Sex | | |
| Men | 223 | 36.8 |
| Women | 383 | 63.52 |
| Degree of dependence | | |
| Total | 536 | 88.9 |
| Partial | 67 | 11.1 |

Regarding main diagnosis, table 2 shows that most patients were diagnosed with dementia syndrome (44.3%), and 22.9% suffered from the sequelae of a stroke – or cerebrovascular accident (CVA). Additionally, out of the 603 patients, 434 (72%) had at least one associated comorbidity (Table 3). Among the comorbidities, the most frequent diagnoses were Systemic Arterial Hypertension (SAH) and Diabetes Mellitus (DM), as presented in table 4. All elderly people underwent medical monitoring to control chronic diseases.

Regarding the oral hygiene of users assisted by IHAS (Table 5), 57.2% had regular oral hygiene, with 8.1% having good hygiene. Oral hygiene, number of comorbidities and degree of dependence did not show a significant association (table 6).

### TABLE 2 – MAIN DIAGNOSIS OF PATIENTS TREATED AT IHAS

| Variable<br>*Main diagnosis (n=603)* | *n* | % |
|---|---|---|
| Demential syndrome | 267 | 44.3 |
| Heamorragic CVA sequelae | 138 | 22.9 |
| Parkinson | 57 | 9.5 |
| Ischemic CVA sequelae | 40 | 6.6 |
| Alzheimer | 33 | 5.5 |
| Psychiatric Illness | 10 | 1.7 |
| Senility | 7 | 1.2 |
| Morbid obesity | 6 | 1 |
| Cardiopath | 5 | 0.8 |
| Amyotrophic lateral sclerosis | 5 | 0.8 |
| Others | 35 | 5.8 |

### TABLE 3 – NUMBER OF COMORBIDITIES

| Number of comorbidities | n (n=603) | % |
|---|---|---|
| None | 169 | 28.1 |
| One | 215 | 35.6 |
| Two | 146 | 24 |
| Three | 61 | 10.3 |
| Four | 12 | 2 |

## TABLE 4 – MAIN COMORBIDITIES

| *Comorbidities* | *Morbidity 1 (%)* | *Morbidity 2 (%)* | *Morbidity 3 (%)* | *Morbidity 4 (%)* |
|---|---|---|---|---|
| SAH | 357 (59.2) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| DM | 26 (4.3) | 148 (24.6) | 0 (0.0) | 0 (0.0) |
| Dyslipidemia | 1 (0.2) | 12 (2.0) | 13 (2.2) | 0 (0.0) |
| Osteoarthritis | 4 (0.7) | 3 (0.5) | 0 (0.0) | 2 (0.3) |
| Hypothyroidism | 11 (1.8) | 8 (1.3) | 13 (2.2) | 2 (0.3) |
| Osteoporosis | 0 (0.0) | 6 (1.0) | 0 (0.0) | 0 (0.0) |
| Hepatitis B | 0 (0.0) | 1 (0.2) | 0 (0.0) | 0 (0.0) |
| Femur fracture | 8 (1.3) | 1 (0.2) | 2 (0.2) | 0 (0.0) |
| Hydrocephalus | 1 (0.2) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Glaucoma | 3 (0.5) | 3 (0.5) | 2 (0.3) | 0 (0.0) |
| Hyperthyroidism | 1 (0.2) | 1 (0.2) | 0 (0.0) | 0 (0.0) |
| Asthma | 1 (0.2) | 1 (0.2) | 1 (0.2) | 0 (0.0) |
| Chronic obstructive pulmonary disease | 0 (0.0) | 0 (0.0) | 5 (0.8) | 0 (0.0) |
| Depression | 13 (2.2) | 14 (2.3) | 10 (1.7) | 2 (0.3) |
| Neoplasia | 7 (1.2) | 15 (2.5) | 12 (2.0) | 4 (0.7) |
| Obesidity | 1 (0.2) | 4 (0.7) | 5 (0.8) | 1 (0.2) |
| arrhythmia | 0 (0.0) | 1 (0.2) | 9 (1.5) | 0 (0.0) |
| Hepatitis C | 0 (0.0) | 1 (0.2) | 1 (0.2) | 0 (0.0) |
| HIV | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (0.2) |
| No morbidades | 169 (28.1) | 376 (62.4) | 530 (87.9) | 591 (98.0) |

## TABLE 5 – ORAL HYGIENE

| Variable | *n (603)* | % |
|---|---|---|
| Oral Hygiene | | |
| Unsatisfactory | 209 | 34.7 |
| Regular | 345 | 57.2 |
| Good | 49 | 8.1 |

## TABLE 6 – ASSOCIATION BETWEEN ORAL HYGIENE, NUMBER OF COMORBIDITIES AND DEGREE OF DEPENDENCE.

| | **Oral Hygiene** | | | p-value |
|---|---|---|---|---|
| | **Good** | **Regular** | **Unsatisfactory** | |
| **Comorbidities** | | | | |
| None | 11 | 90 | 60 | 0.127 |
| One | 17 | 110 | 86 | |
| Two | 15 | 100 | 41 | |
| Three | 6 | 39 | 16 | |
| Four | 0 | 6 | 6 | |
| **Degree of dependence** | | | | |
| Total | 52 | 308 | 187 | 0.479 |
| Partial | 8 | 37 | 22 | |

## DISCUSSION

The IHAS of the BN carries out multidisciplinary home monitoring of elderly people living at home, also having the following objectives: keeping the patient within their family environment (enabling faster recovery and with a lower risk of infection), improving quality of life, prioritize prevention and health promotion, overcome patients' mobility difficulties, reduce the number of hospital admissions, speed up the release of beds in the reference hospital, encourage family participation in patient care, favor humanization of care and function as a setting for study and scientific research.

Of the 603 records of elderly people registered in IHAS, there was a prevalence of females (63.52%). According to IBGE data from the last census (2010), there are around 24% more elderly women over 60 years old than men in Brazil (2). Some studies attribute the name "feminization of old age" to this phenomenon (8,9).

The present stud showed that IHAS has many elderly people, with an average age of 82.52 years, with the oldest patient being 102 years old. Associated with this high average age,

most elderly people (88.9%) were completely dependent, which made it mandatory for the caregiver to perform BADL. Similarly, Oliveira *et al.* evaluated 123 elderly people living at home who were an average of 81.3 years old and 62.6% were women, as well as a percentage of 89.4% in relation to dependence (10).

Dementia syndrome was the main diagnosis in 44.3% of patients in this study. Dementia increases the risk of oral diseases (mainly periodontal disease and the need for tooth extraction) due to the loss of self-care capacity due to decreased motor skills, leading to poor oral health, a common condition found in patients with dementia (11 ,12). Gil-Montoya *et al.* showed that even patients with early-stage cognitive impairment have poor oral hygiene, with greater accumulation of bacterial plaque and gingival inflammation (13). The study by Elsig *et al*. found 100% of visible plaque in participants with dementia (14). Periodontal disease has been implicated as a risk factor for the onset and progression of dementia (12). Dementia also encourages the formation of a vicious circle, since it impairs chewing through impaired motor skills and lack of chewing, which consequently accelerates dementia by reducing blood flow and brain activity (15).

The increase in life expectancy leads to a greater prevalence and incidence of morbidities, characterized by an increase in chronic degenerative diseases (3). In the study, only 28.1% had no comorbidities. The main comorbidity found was arterial hypertension (59.2%), followed by Diabetes mellitus (29%). The study by Pimenta *et al.* corroborates these data with 69.9% of the elderly people evaluated being hypertensive, and 17.7% diabetic (16). It has been reported that hypertension in frail elderly people results from stiffening of the arteries, representing an increased risk for cognitive decline, loss of autonomy and cardiovascular mortality (17). Diabetes mellitus, in addition to the risk of mortality, has also been directly associated with loss of muscle function and strength (18).

The high degree of dependence of the patients evaluated (88.9%) means that the elderly people necessarily require a caregiver for all necessary activities. They present complex care demands, which make the caregiver prioritize other actions in relation to oral health care (19). The non-prioritization of oral care is reflected in our study through a very high rate of unsatisfactory oral hygiene (37.3%). Oliveira *et al.* found precarious oral health in the elderly due to caregivers with a lack of knowledge regarding oral care and difficulties in implementing it in practice, when guided (19). In our study, no significant relationship was found between degree of dependence and oral hygiene. This fact may be because patients who do not have a degree of total dependence, present partial dependence along with advanced age, representing some loss of motor skills and, thus, ability to perform adequate oral hygiene.

The oral cavity under appropriate conditions can have hundreds of microorganisms in homeostasis (20) and poor oral hygiene is one of the factors that alters the balance of the oral microbiota (21). These changes can invade subgingival sites and enter the bloodstream, as well as cross the digestive system and promote an imbalance in the intestinal flora, leading to inflammatory bowel disease. One example is the bacteria *P. gengivalis*, which proliferates due to poor oral hygiene and periodontal disease, with the ability to destroy the intestinal barrier, resulting in a systemic inflammatory response, aggravating the patient's other systemic diseases (22).

Poor oral conditions in patients with cardiovascular disorders have been related to a predisposing factor for the development of bacterial endocarditis, which, added to advanced age as another predisposing factor, makes patients extremely vulnerable to this infection (23). Another disease with a high mortality rate is aspiration pneumonia, presenting an increased risk in frail elderly people with dysphagia and poor oral hygiene (24).

The importance of individualized care, seeking to fit into a daily oral health routine, is necessary for frail elderly patients. Brushing teeth with fluoridated toothpaste twice a day is recommended, which can increase up to 5000ppm of fluoride in individuals at high risk for caries, especially in patients with root cavities (25). Kossioni *et al.* described a practical guide to help promoting oral health in frail elderly people (26). The authors highlight the suitability of a toothbrush that adapts to the caregiver and the patient, such as an electric toothbrush, a toothbrush with a better grip or one adapted to the patient, interdental brushes, and a dental floss adapter. The same researchers emphasize that tongue scrapers or soft brushes should be used to remove bacteria and dirt, and extra attention should be given to bedridden patients with dysphagia to clean the oral mucosa with a soft brush or gauze, aiming to remove food debris and biofilm to avoid bronchopulmonary aspiration (26).

By understanding the patients' conditions, it is possible to plan better care. It was realized that caregivers need to be better guided and stimulated on a constant and recurring basis. As visiting all patients constantly is unfeasible, teleconsultations are suggested in order to assess how and when oral hygiene is being performed and the problems presented. It is also necessary to carry out cohort studies to verify the evolution of the general health and oral health of the patients treated.

## CONCLUSION

The profile of the elderly people assisted was that of long-lived elderly people, with the vast majority having dementia syndrome as their main diagnosis, presenting comorbidities, with a degree of total dependence and with a predominance of females. There is a high prevalence of elderly people living at home with inadequate oral hygiene, however, there was no association between this aspect and the degree of dependence or comorbidities. Therefore, it is imperative that elderly people living at home receive guidance and undergo meticulous and ongoing monitoring, in conjunction with their caregivers to promote improvements in the oral hygiene of these patients.

The authors declare no conflicts of interest.

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CASE REPORT

# ALVEOLAR RIDGE AUGMENTATION WITH CUSTOM 3D-PRINTED BLOCK GRAFT: CASE REPORT

## *AUMENTO DO REBORDO ALVEOLAR COM ENXERTO EM BLOCO IMPRESSO PERSONALIZADO: RELATO DE CASO*

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## ABSTRACT

The use of the technology CAD/CAM (computer aided design/computer aided manufacturing) and 3D (three dimensional) to alveolar reconstructions in implant dentistry allows detailed preoperative planning, the design of the desired grafting result, and the virtual evaluation of the result in relation to the prosthetic reconstruction. This paper aims to details the synthetic bone graft made through this technology, followed by the installation of osseointegrated implants and prosthetic rehabilitation in a bone imperfection in the jaw. A 22-year-old man attended the clinic due to a tooth avulsion of the four lower incisors with significant vertical bone loss of alveolar ridge. Because of the extensive bone loss, it was made a prototyped printed block graft. The intraoral scan and the generated image files were sent to the virtual planning center. First, it was necessary a surgery to install the block graft. After the healing process, it was made a surgery to put two osseointegrated implants. Three months later, temporary fixed prostheses on implants were made to conditioning the peri-implant soft tissues and the progressive loading of the implants. The increase of the alveolar ridge using personalized printed block graft was presented as a technique with numerous advantages, since it does not require a donor site, reduces the surgical time and presents perfect adaptation of the block to the bone imperfection, resulting in a less postoperative morbidity. This technique is indicated to cases of severe bone imperfections, aims to optimize results, and provide less discomfort to the patient.

**Keywords:** bone graft; CAD/CAM; 3D print; hydroxyapatite; dental prosthesis; alveolar ridge augmentation.

## RESUMO

A utilização da tecnologia CAD/CAM (*computer aided design/computer aided manufacturing*) e 3D (tridimensional) para reconstruções alveolares na implantodontia permite o planejamento pré-operatório detalhado, o design do resultado desejado do enxerto e a avaliação virtual do resultado em relação à reconstrução protética. Este trabalho objetiva detalhar a técnica cirúrgica de enxerto ósseo sintético confeccionado por meio dessa tecnologia, seguido da instalação de implantes osseointegráveis e reabilitação protética em um defeito ósseo na mandíbula. Paciente masculino, 22 anos, compareceu à clínica por avulsão dos elementos 32, 31, 41 e 42 com significativa perda óssea vertical de rebordo alveolar. Devido à extensa perda óssea, realizou-se enxerto em bloco prototipado impresso. O escaneamento intraoral e os arquivos de imagem gerados foram enviados ao centro de planejamento virtual. Primeiramente, foi realizada a cirurgia para instalação do enxerto em bloco. Após o período de cicatrização, foi realizada cirurgia para instalação de dois implantes osseointegráveis. Esperado o período de três meses a partir da instalação dos implantes, foi realizada a confecção de próteses provisórias fixas sobre implantes a fim de realizar o condicionamento dos tecidos moles peri-implantares e o carregamento progressivo dos implantes. O aumento do rebordo alveolar através do uso de enxerto em bloco impresso personalizado apresentou-se como uma técnica com inúmeras vantagens, por não necessitar de sítio doador, reduzir tempo cirúrgico e apresentar perfeita adaptação do bloco ao defeito ósseo, resultando em menor morbidade pós-operatória. Essa técnica é uma indicação para casos de defeitos ósseos severos, visando a otimizar o resultado e a propiciar menor desconforto ao paciente.

**Palavras-chave:** Enxerto ósseo; CAD/CAM; impressão em 3D; hidroxiapatita; implante dentário; aumento do rebordo alveolar.

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## INTRODUCTION

Implant dentistry is a vast field within dentistry, which demands a great biological and anatomical knowledge from the dental surgeon. In tissue reconstruction, the use of autogenous graft is the gold standard due to its biocompatibility. On the other hand, it presents greater cases of postoperative morbidity, surgical time extended due to the need for two surgical areas, and a higher percentage of complications, such as, the presence of irreversible sequelae. In addition, the presence of limitations related to the bone volume available at the donor site has made the use of this technique increasingly smaller (1-3).

As an attempt to mitigate this problem, the use of bone substitutes gained greater popularity and the adoption of guided bone regeneration (GBR), performed alongside bone particles associated with the use of a membrane as a physical barrier, became widely expanded and documented in the literature. The four main elements required for a successful GBR have been described as: primary wound closure, space maintenance, clot stability, and a correct angiogenesis to provide access to the necessary cells, nutrients, and oxygen for tissue regeneration (1-3). Space maintenance is associated with the proper management of soft tissues and membrane properties. On the other hand, angiogenesis and blood clotting formation depend mainly on the native alveolar bone architecture (4). Thus, for larger reconstruction areas, the difficulty of correct tissue management can lead to failure, so there is a need for an experienced surgeon due to limitations in the vertical increase of the alveolar ridge.

Given the evidence and with the breakthrough of digital dentistry, other solutions have been studied. The use of CAD/CAM and 3D printing for digital reconstruction and graft fabrication for procedures for increasing the alveolar ridge has significant benefits for the patient and the clinician. First, it allows detailed preoperative planning, the desired design graft outcome, and the virtual evaluation of the desired outcome in relation to the final prosthetic reconstruction. In addition, it has the potential to produce personalized grafts with optimal adaptation and stability, which are crucial factors for success in bone augmentation procedures. Additionally, it allows a significant reduction in operative time, usually resulting in a lower rate of complications and intercurrences during healing, less discomfort, and an improvement in the overall patient experience. Lastly, the CAD/CAM milling process can be applied to a wide range of graft materials, including alloplastic, and of allogeneic and xenogeneic origin. It allows the practitioner to use the material of their choice based on its properties for each clinical scenario. Finally, the 3D printing process, although currently limited to alloplastic materials, has the potential to optimize the surface topography and microporous architecture of these materials, significantly improving their regenerative potential and success. Thus, it is as a promising technology for better clinical results related to bone augmentation (5).

This work aims to expose a surgical technique of a synthetic bone graft made by CAD/CAM technology, followed by installation of osseointegrated implants and their prosthetic rehabilitation in a bone defect in the anterior region of the mandible.

## CASE REPORT

The Ethics Committee in accordance with the National Health Council approved this present report under protocol number: 66073122.0.0000.5256.

A 22-year-old man attended the Implant Dentistry Department at the Navy Central Dentistry complaining of avulsion of the four lower incisors with significant vertical bone loss of alveolar ridge and need for rehabilitation in the anterior region of the mandible. Bone graft procedure was indicated for the installation of osseointegrated implants. At that point, the patient was using a temporary removable partial prosthesis to rehabilitate the region. All procedures were explained verbally and in writing to the participant, who signed an informed consent form, detailing the stages of the research. The patient underwent preoperative cone beam computed tomography (CBCT) with soft tissue clearance for evaluation of available bone volume and planning for tissue reconstruction surgery (Figure 1). Additionally, a complete scan of the arcades was performed to obtain the file in STL (Standard Triangle Language), along with DICOM images (Digital Imaging and Communications in Medicine), generated from the CBCT examination, which were sent to the company Plenum® (Jundiaí, Sao Paulo) to produce the personalized graft. From DICOM files, a trained professional performed in a specific software (Mimics and 3-Matic, Materialise, Belgium), the drawings (virtual planning) of the personalized grafts, which were previously approved, and then made by means of additive manufacturing in a 3D printer suitable for ceramic prints (CeraFab 7500, LITHOZ). The project of the graft was presented in a video call held along work team. Adjustments and considerations were made, and the block was approved for manufacture (Figure 2). The custom

piece was made using lithography-based ceramic manufacturing (LCM), its process consists in printing the virtual part (previously drawn and exported in STL file) in resin containing the desired bioceramic, in this case, hydroxyapatite (HA). After the printing process of the parts was done, a cleaning with solvent was performed to remove excess resin inside the pores. Then, the piece was sintered in a muffle furnace at 1000 °C. After dimensional measurement, it was packed with primary and secondary wrappers in blister and surgical paper, then sent for sterilization by gamma irradiation 25kGy (Sterigenics, Jarinu, Sao Paulo). Right after the arrival of the block graft at the Navy Central Dentistry, the surgery was scheduled. As a drug protocol, it was prescribed to the patient: amoxicillin 500mg every 8 hours for 7 days, with an initial dose of 1g, 1 hour before surgery; dexamethasone 4mg, single dose of 8mg, 1 hour before surgery; dipyrone 500mg every 4 hours, in case of pain; and mouthwash with 0.12% chlorhexidine twice a day for seven days.

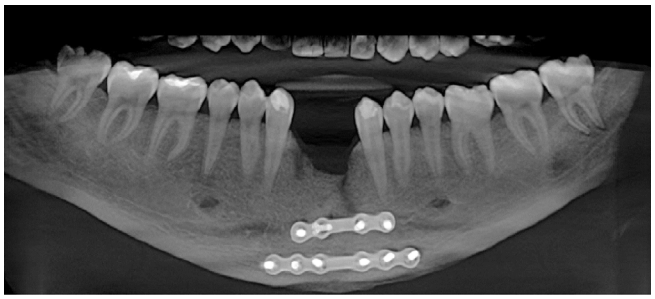

**Figura 1:** *Initial CBCT, panoramic reconstitution.*

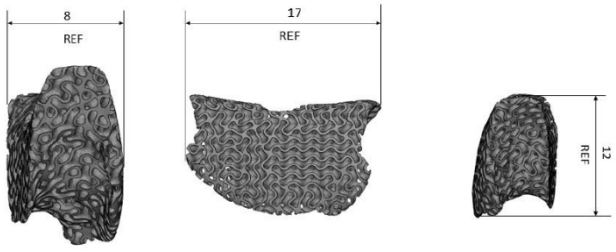


**Figura 2 :** *Digital planning with graft dimensions in millimeters.*

After preoperative planning procedures through CBCT and clinical examination, the patient was submitted to the three-dimensionally printed block bone graft surgery. At the beginning of surgery, he received a local anesthesia of lidocaine 2% with epinephrine 1:100,000, to block the mental and incisor nerves, associated with infiltrative anesthesia in the vestibular and lingual regions. An incision was made at the top of the remaining medial alveolar ridge from the left lower canine to the opposite side. Two incisions were made for vestibular relief in the distal portion of both canines, considering the position of the mental foramina. Then, a subperiosteal total detachment of the flap was performed and the relief of the vestibular flaps was made by means of superficial incisions (depth of 1 to 2 mm) with the scalpel blade 15C in the vestibular periosteum. This way, tissues disclosure could be made to obtain a relaxation of the mucosa until it exceeds the occlusal plane of the remaining teeth. Perforations were made in the cortical bone with fine burs until reaching the medulla. This step is essential to obtain the vascularization of the graft. Afterwards, a copy of the block graft was positioned to check its adaptation, once the template is checked and approved, there is no need to adjust the graft itself. This step was followed by preparation of the receptor site with a cylindrical bur. Also, blood was collected from the patient to produce plasma-rich fibrin (PRF) and, after being centrifuged, the i-PRF was added to the block graft, producing a membrane to be placed on the resorbable membrane. Once the adaptation was verified, the graft was fixed with the screw already in the previously planned position. The gaps between the block and the native bone were filled with a fine-grained particulate bone (Plenum®Osshp, Plenum®) and coated with the restorable membrane of xenogenic origin (BioGide®, Geistlisch®) to guarantee the coverage of the entire graft with an extension of 2 mm. Besides that, a PRF membrane was placed on this membrane to optimize the healing process. Finally, the suture was performed in two planes, firstly on a horizontal mattress to bring the flap closer to the surface, and then simple sutures with 4-0 polypropylene thread (Optilene Blue, Braun®) (Figures 3A-F).

Eleven months after the bone reconstruction surgery, digital planning was carried out for the preparation of a surgical guide through the CBCT and the STL scan file, so that osseointegrated implants could be installed (Figure 4). The participant underwent local anesthesia with lidocaine 2% alongside epinephrine 1:100,000. An incision was performed, without vertical relaxing incisions, and full thickness flap elevation. Guided surgical instrumentation was performed with external irrigation with sterile saline for the installation of two regular plenum implants 3.5x13mm lot 90413 (Plenum®, Jundiaí, SP). Torque installation was 30N.cm and the implant were closed with a cover (Figures 5A-D). At the end, a simple suture was performed as a first intention, without generating tension to soft tissues, with Nylon Soft Blue 5-0 (Techsuture®) thread. The patient continued to use temporary removable partial prosthesis, done after healing from bone reconstruction surgery.

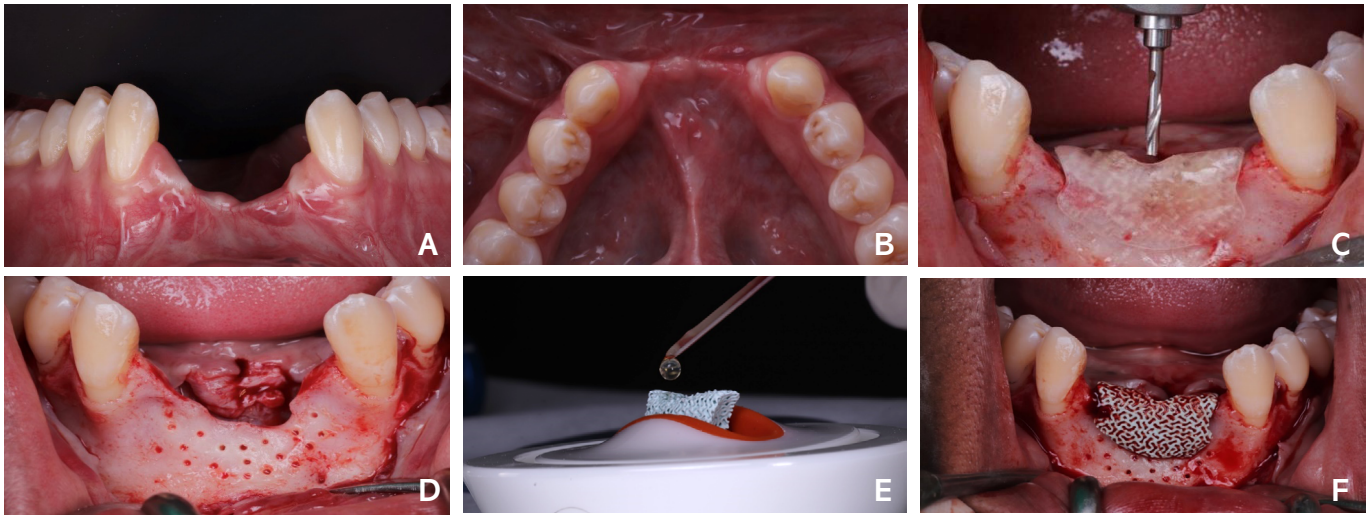


**Figure 3: A –** *Initial intraoral preoperative aspect - frontal view;* **B –** *Initial intraoral preoperative aspect- occlusal view;* **C –** *Test of template osteotomy;* **D –** *Bone aspect similar to Swiss cheese after perforations in the cortical;* **E –** *Addition of i-PRF in the block graft;* **F –** *Proof and fixation of the block graft on the bone defect.*

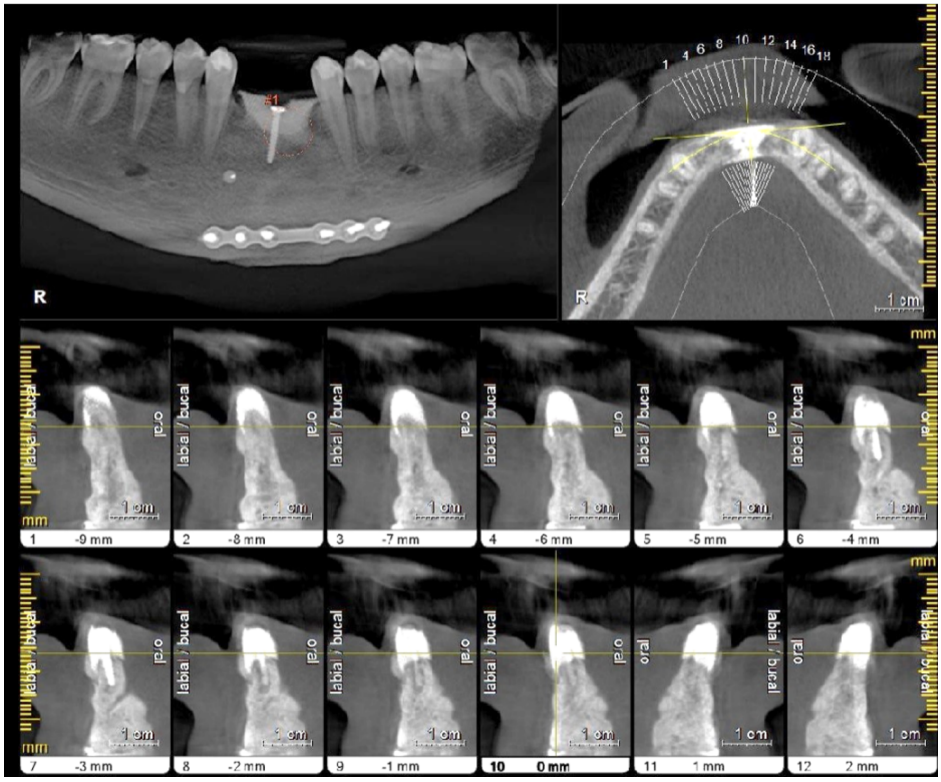


**Figure 4:** *CBCT after eleven months of graft healing, showing the juxtaposition of the graft to the native bone; panoramic, axial and transaxial reconstitution.*

Two months after the installation of the implants, due to the need of increasing keratinized gum band in the region, it was decided to perform a free epithelial graft surgery. A strip of epithelial tissue was removed from the palate. Then, an incision was made dividing the flap and the free epithelial graft was fixed in the region. The Nylon Soft Blue 5-0 (Techsuture®) thread was used (Figure 6).

After four months of healing, a reopening surgery was performed, in which was possible to confirm the osteointegration of the implants. Two transmucosal minipillars of 2mm high with their respective provisional cylinders (Plenum®, Jundiaí, SP) were installed. After occlusal adjustment and polishing were done, a fixed provisional prosthesis was performed directly in the mouth, for minipillars fixation. The patient is using the provisional fixed partial prosthesis to perform the progressive loading of these implants (Figure 7A-D).

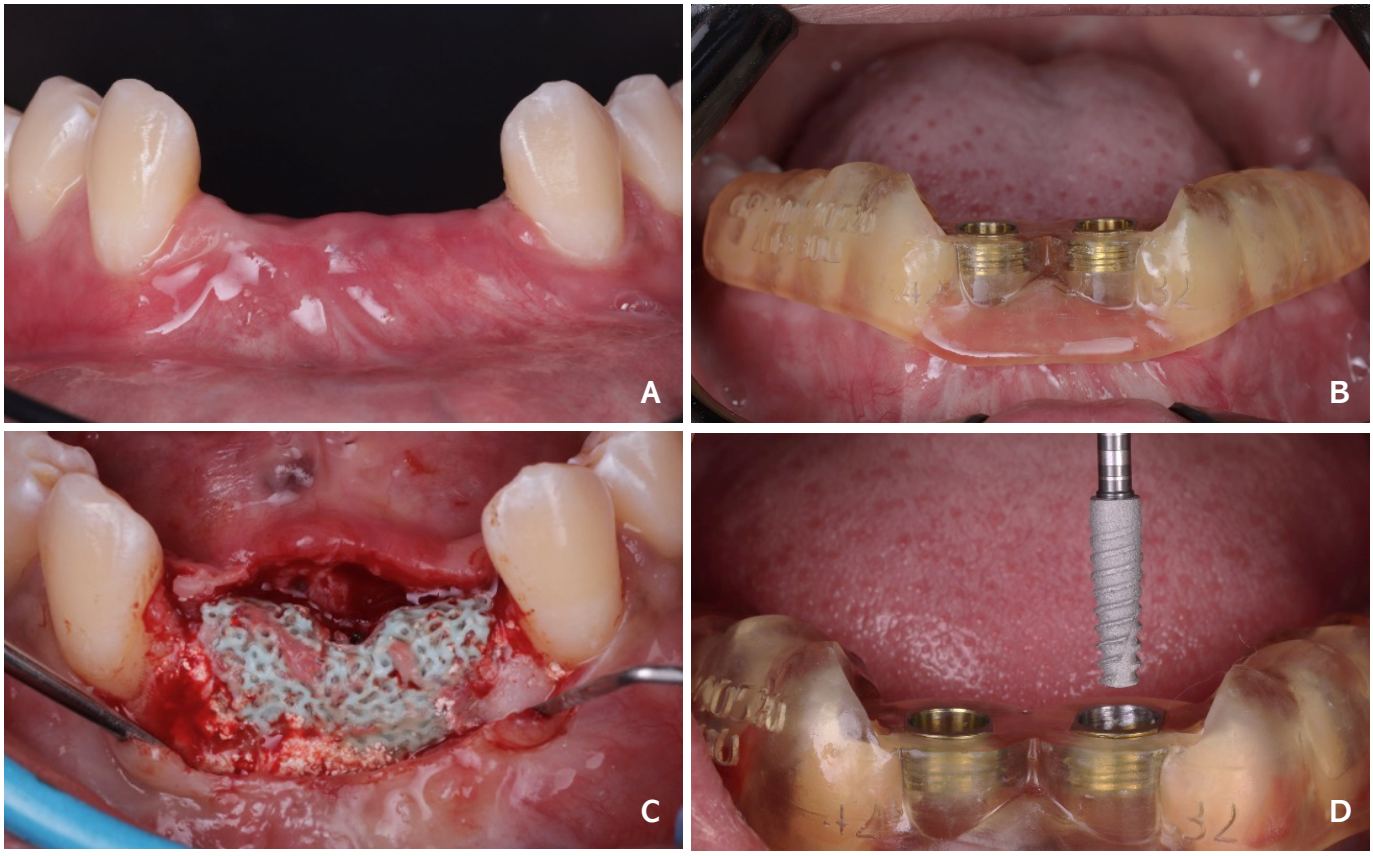


**Figure 5: A -** *Intraoral appearance before implant installation;* **B -** *Proof of surgical guide;* **C -** *Graft appearance after flap opening;* **D -** *Installation of Regular Plenum implant 3.5x13mm.*

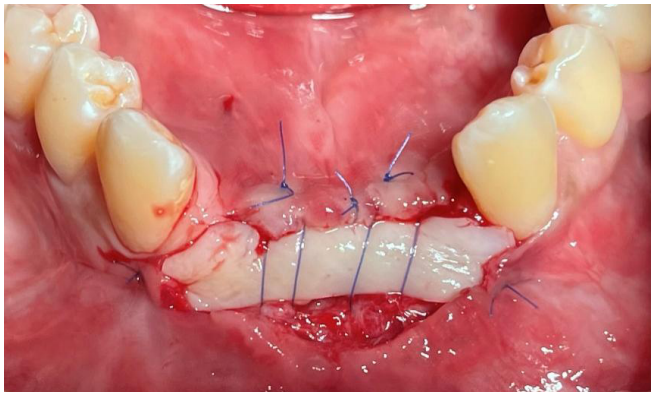

**Figure 6:** *Intraoral aspect during surgery for grafting free epithelial tissue.*

## DISCUSSION

Several techniques are described in the literature for bone augmentation in atrophic jaws, such as onlay/inlay bone grafting, GBR, edge expansion and osteogenic distraction (6-10). Although it has already been shown that in all these techniques there is an edge increase, each of them present risks of complications and potential dimensional loss of the graft (11). In addition, all these techniques require perioperative manual adjustments of graft. This process is challenging and time-consuming and can lead to an unsatisfactory adaptation of the graft to the bone defect (12). This maladaptation of the graft to the receptor site is a major problem for the increase of the alveolar border since the mechanical instability of the graft can compromise the biological response and consequently the treatment outcome (12).

Currently, 3D scanning technology and new bone substitutes, with excellent osteoconductive characteristics, are promising to open new alternatives in relation to alveolar ridge augmentation techniques. It is possible to produce a precise 3D format calculated by the computer, creating a synthetic bone substitute in the exactly required format (13). This technology was used in this case report inspired by a described technique made for anterior alveolar ridge of the mandible reconstruction. The Plenum® Oss 3Dβ fit was used, a patient-specific bone graft with customized dimensions, produced from the additive manufacturing process (3D printing), and composed of hydroxyapatite, with complex geometry and faithful to the anatomy of the bone tissue to be reconstructed. In the bone graft planning process, an STL file was obtained, which associated with additive manufacturing technology, resulted in the production of these parts that integrate personalized medical devices, sub-classified as “patient-specific” according to RDC Nº 305/2019 (14).

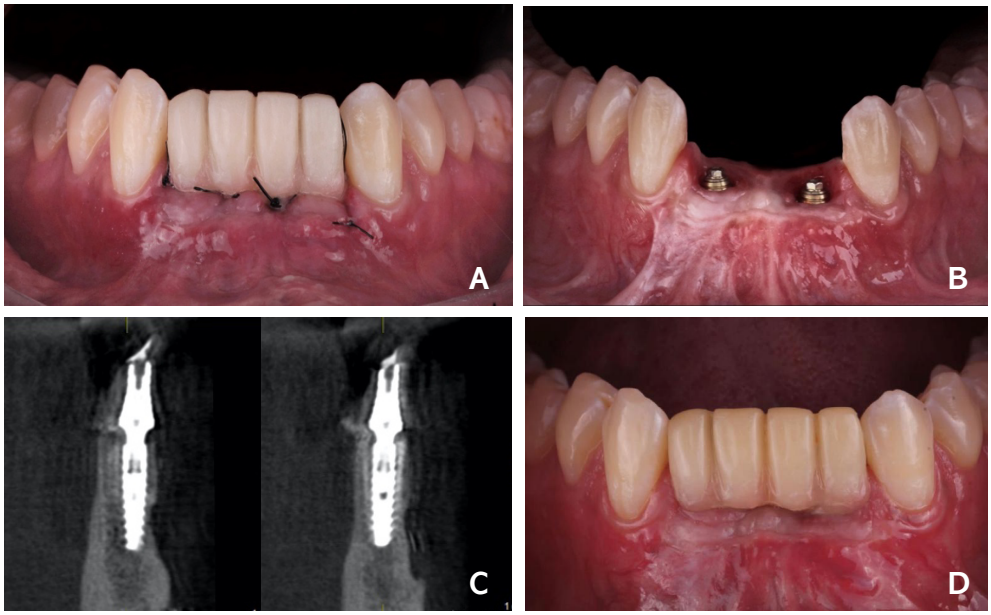


**Figure 7: A -** *Intraoral aspect at the end of the surgery reopening and preparation of direct fixed provisional prosthesis;* **B -** *Front view of the minipillars after soft tissue healing;* **C -** *Axial sections of the tomography examination in the center of the osteointegrated implants.* **D -** *Final image of the current gingival aspect, after 12 months with progressive loading of the implants, notice the presence of adequate keratinized tissue. (Sequence from left to right).*

The digital approach has many benefits, such as avoiding the need for a donor site and ensuring the perfect adaptation of the block to the bone defect. In our case, because it is a defect greater than 6mm in height and depth, the block graft was anchored with a screw to allow adequate fixation at the receptor site and three-dimensional stabilization to support muscle forces. That is the reason why the block graft onlay technique was chosen (15).

Although autologous bone, extracted from intraoral or extraoral sites, is currently the most reliable material for alveolar ridge augmentation, with the highest success rate, the use of these block grafts has many disadvantages, such as the need for multiple interventions, limited bone availability, the risk of morbidity at the donor site, and the high rate of graft resorption (16). Because of this, it is common for patients to prefer a bone substitute block over an autograft block, collected from an intra or extraoral site. It was no different in this case, since the patient had other mandibular fractures, which required the surgical approach of rigid fixation with plate and screw, a scarce donor area for performing an autologous graft, considering also the patient's preference.

There is a variety of bone substitute materials available as allogeneic, xenogeneic, or synthetic/alloplastic (16-19). An ideal bone substitute should be able to three-dimensionally regenerate complex anatomical defects (16,20). It must be biocompatible, osteoconductive, and osteoinductive, stimulating appropriate cell differentiation through signaling factors, so that the arrival of pluripotent cell types can be allowed (16,19). It should also be structurally similar to bone, performing mechanical activity similar to native structures, and allowing adequate function and dissipation of loads (16,19), besides being synthetic and not from human or animal origin (21,22). Finally, it should be easily made into various shapes. For this reason, materials with three-dimensionally made pores are currently used as bone substitutes (16,19). The 3D structure of the pores provides space for a new bone formation, supports cell proliferation and maintains its differentiation function, acting similarly to the extracellular matrix, and its architecture defines the final shape of the new bone (16,19). The graft used was made with macrogeometry in such a way to facilitate angiogenesis in the area, making it cell proliferation easier.

Synthetic grafts are usually made of calcium phosphate bioceramics, such as hydroxyapatite, β-TCP (β-tricalcium phosphate), or the combination of both (23). β-TCP was evidenced as a bone substitute due to its cell's reabsorption, usually osteoclasts, which cause acidification of the medium, dissolving β-TCP (24-26). This process makes β-TCP a restorable compound, allowing a fast bone neoformation (24,27,28). Hydroxyapatite, on the other hand, is not a restorable material, and its use is suitable to extensive regions that need to remain as a framework for bone neoformation. Moreover, both materials can be obtained from

various production methods. One of them is 3D printing, which has several advantages. The use of this manufacturing process has been described since 1994 in medicine, which led to the development of personalized grafts for bone reconstruction in rehabilitation with implants (29,30). The present study used this 3D printing technology to produce a hydroxyapatite block graft, a technique that reduces material waste, as it is additive. In addition, as there is a need for structural support to the implants installed in the area, due to the large extension of it, the use of a graft such as the one composed of β-TCP would not be indicated because of its resorption, therefore, in theory, it would not work as a structure for a future implant.

Clinical trials using 3D ceramic structure for bone regeneration have already been developed and have obtained satisfactory results (,), which confirm its clinical applicability (31,32). In the present study, a hydroxyapatite graft was used as the scaffold. This material has already been widely used for repair and augmentation of hard tissues in preclinical and clinical studies (19,33-36). It is biocompatible, osteoconductive and has osteoinductive properties, has appropriate porosity for the diffusion of nutrients, and the invasion of vascularization of the surrounding tissue. In addition, its surface chemistry allows the cells to adhere and express the osteogenic phenotype (33-36), presenting adequate mechanical properties. Moreover, it is synthetic and economical, and capable of easily forming an adequate anatomy (33,36). All these features have been observed so far, in this case. The patient did not present biological alteration compatible with any type of reaction to a foreign body or allergy. When the implant installation surgery was performed, the biological integration of the graft to the patient's bone tissue was stated due to the feasibility of surgical instrumentation without graft displacement. Only the fact of being economical is debatable, because as it is a material yet to be marketed, there is no final value of the product for analysis.

In this report, we had the opportunity to use a framework made from the CAD/CAM system of anatomical format custom-made, which adapted perfectly to the recipient site, without the need for any changes during surgery. This precision may have contributed to the biological integration of the graft, culminating in excellent clinical results. The treatment time was considerably reduced, with clear benefits for the patient. Indeed, the perioperative time is not consumed by the repeated conformation of the graft to the native bone as in conventional procedures (13,37,38). The procedure allows a faster closure of the surgical wound, avoiding possible sources of graft contamination and reducing postoperative discomforts, such as swelling and pain, resulting from long and difficult surgical procedures (37). Another advantage is that the graft is completely reproducible, so if there are any complications during surgery, it is possible to have an extra graft available on the operating table. Therefore, the entire procedure is simplified and more accessible even to less experienced surgeons (37,38).

In this study, PRF was added to the operative site, since this technique allows a the delivery of an aggregate of proteins and growth factors that can promote wound healing and tissue regeneration at the site of surgery. As reported in previous studies PRF can be effective in the administration of many growth factors, such as: platelet-derived, endothelial, vascular endothelial, fibroblast, among others (39,40). All these factors can promote tissue healing and regeneration (41,42).

As potential limitations of the present technique, there are motion artifacts during CT scans and the presence of restored teeth or metal restorations near the toothless area (38). The CT scan data set may be quite imprecise, and the presence of metallic artifacts may complicate the CAD process and the personalized design of the graft, in addition to the calibration of the professional who will operate the tomograph being fundamental for the success of the technique, as it can be considered technologically dependent.

Finally, the time between the tomographic images and the time of surgery is another limitation of this technique. The entire procedure must be done within a few weeks, to prevent bone remodeling processes from altering the patient's anatomy. In fact, changing the residual anatomy can result in inaccuracy of the custom-made graft during surgery. Beyond that, the timesaving with the use of the CAD/CAM approach is still controversial, even though the surgical time is considerably reduced, more time is required during the virtual planning, design and manufacture of the custom-made graft (43).

Long-term follow-up of this report is necessary because, up to this point, there has been twenty months of follow-up since the installation of the implants, and thirteen months since the provisional loading. To the best of our knowledge, there is only one ongoing clinical trial described in the literature (44), which warns of the importance of developing randomized clinical trials involving the above theme to enable the formation of more

robust scientific evidence and increase the safety of professionals when using this technique.

## CONCLUSION

The increase of the alveolar ridge with personalized patient-specific block graft was presented as a technique with numerous advantages, such as the absence of the need for a donor site, reduction of surgical time, and excellent block adaptation to the bone defect, resulting in lower postoperative morbidity. Therefore, this technique is an alternative to be generally used by dentists in cases of severe bone defects, to optimize the result and provide less discomfort to the patient.

The authors declare no conflicts of interest.

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LITERATURE REVIEW

# CONTRIBUTION OF DIGITAL TECHNOLOGY TO THE SURGICAL TECHNIQUE OF MINISCREW INSERTION: A LITERATURE REVIEW

## *CONTRIBUIÇÃO DA TECNOLOGIA DIGITAL PARA A TÉCNICA CIRÚRGICA DE INSERÇÃO DE MINI-IMPLANTES: UMA REVISÃO DE LITERATURA*

Yasmina El Honsali[1], Hajar Ben Mohimd[2], Fatima Zaoui[3], Hicham Benyahia[4]

## ABSTRACT

Orthodontic miniscrews are used to achieve absolute anchorage. Their insertion technique is simple but must be precise to avoid intra- and postoperative complications. This study aimed to review the literature on the role of digital technology in the precise placement of miniscrews and to describe the different stages of the insertion guide manufacturing chain. The databases used were PubMed, Science Direct, and Google Scholar, including the following English descriptors: "Orthodontic Anchorage Procedures," "Cone Beam Computed Tomography." Digital technology improves the accuracy of miniscrew placement by using 3D imaging to assess the quantity and quality of bone and the proximity of anatomical structures in the area to be implanted. By combining 3D imaging with the new techniques of 3D printing and virtual planning, the orthodontist can obtain a personalized placement guide for the patient using computer-aided design and manufacturing techniques. A digitally-assisted miniscrew insertion system is a promising technique for precise and safe miniscrew insertion but cannot be used routinely. Therefore, large-scale studies are needed to map miniscrew insertion in different areas, considering ethnicity, gender, and different anatomical characteristics.

**Keywords:** Workflow, Orthodontics, Orthodontic Anchorage Procedures, Cone-Beam Computed Tomography.

## RESUMO

Mini-implantes ortodônticos são usados para obter uma ancoragem segura. Sua técnica de inserção é simples, mas deve ser precisa para evitar complicações intra e pós-operatórias. Este estudo teve como objetivo revisar a literatura sobre o papel da tecnologia digital na colocação precisa de mini-implantes e descrever as diferentes etapas da cadeia de fabricação do guia de inserção. As bases de dados utilizadas foram PubMed, Science Direct e Google Scholar, incluindo os seguintes descritores em inglês: "Orthodontic Anchorage Procedures", "Cone Beam Computed Tomography". A tecnologia digital melhora a precisão da colocação dos mini-implantes usando imagens 3D para avaliar a quantidade e qualidade do osso e a proximidade das estruturas anatômicas na área a ser implantada. Ao combinar imagens 3D com as novas técnicas de impressão 3D e planejamento virtual, o ortodontista pode obter um guia de posicionamento personalizado para o paciente usando técnicas de design e fabricação auxiliadas por computador. Um sistema de inserção de mini-implantes assistido digitalmente é uma técnica promissora, mas não pode ser usado rotineiramente. Portanto, são necessários estudos em larga escala para mapear a inserção dos mini-implantes em diferentes áreas, considerando etnia, gênero e diferentes características anatômicas.

**Palavras-chave:** Fluxo de Trabalho, Ortodontia, Procedimentos de Ancoragem Ortodôntica, Tomografia Computadorizada de Feixe Cônico

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## INTRODUCTION

Miniscrews are widely used in orthodontic practice thanks to their many advantages: simple surgical placement and removal, small size, relatively low cost, and minimal postoperative requirements (1). However, miniscrews placement can be problematic considering the lack of knowledge of the implanted site anatomy, especially in the palate and the infra-zygomatic ridge, which can sometimes lead to failure. Several methods have been described in the literature to optimise the correct placement of miniscrews and improve their success rate based on digital technology (2-4). Digital technology has revolutionised dentistry, first in implantology and now in orthodontics. Thanks to cone beam computed tomography (CBCT) analysis, it is possible to plan the position of the miniscrew, avoiding anatomical pitfalls. Then, using sophisticated software, we can choose the type of miniscrew, as well as its orientation and depth of insertion, using the same technique as for implant planning. Finally, for greater precision during miniscrews placement, 3D printing from digital impressions and CBCT produces surgical guides. This review aimed to assess the value of CBCT in improving the placement accuracy of miniscrews and to itemise the manufacturing workflow of insertion guides.

## LITERATURE REVIEW

A non-systematic electronic search was performed in the PubMed, Science Direct, and Google Scholar databases using the following English descriptors: “Orthodontic Anchorage Procedures,” “Cone Beam Computed Tomography.” using the Boolean operator “AND.” Research articles, literature reviews, randomized clinical trials, and case reports pertinent to the subject, published from January 2000 to July 2023, in English or French language were included. Exclusion criteria included articles with disparities in the proposed theme, abstracts, and letters to the editor. A total of 390 articles were found, 21 duplicates were eliminated using Zotero software, and the remaining 369 articles were examined manually. Finally, 39 articles met the selection criteria for inclusion in this study.

### *Current state of knowledge*

#### Tomographic determination of miniscrews site insertion:

**CBCT indication:**

The use of preoperative CBCT is not systematic, it is justified in cases where (5,6):

- Retro alveolar images show real root proximity;
- The noble anatomical structures are close to the insertion site;
- Routine cephalometry has highlighted the likelihood of insufficient bone quality or quantity and the risk of complications;
- Implant sites are being mapped for a given population.

#### Recommended sites for miniscrew placement:

Several scientific studies have been carried out on groups of patients to determine the safe areas for inserting miniscrews, based on the interradicular spaces and the thickness of the cortical and alveolar bone with the help of CBCT (7-11). However, given anatomical variability, carrying out a personalised analysis is still necessary in some particular cases (periodontitis, anatomical variations, clefts, etc.).

**Interradicular miniscrew:**

In the maxilla, the most favourable vestibular interradicular sites are located mesial and distal to the first molar and between the canine and lateral incisor, all located 6 mm away from the cementoenamel junction (CEJ). The recommended sites in the palatal interradicular zone are from the mesial of the second molar to the distal of the first premolar 4 mm away from the alveolar crest (AC). In the mandible, the most favourable vestibular interradicular sites are between the first and second molar and between the first and second premolar, both 5 mm away from the CEJ. For the anterior and posterior lingual part of the mandible, the available data is limited, since these areas are rarely used for miniscrew placement (8).

A vertical insertion angle of 30 and 45 degrees (12) and a distal tipping of 10° to 20° (13) may provide better contact between the cortical bone and the miniscrew without damaging the roots.

**Palatal miniscrew:**

- **Posterior area**

The palatal posterior supra-alveolar area is a suitable site for posterior insertion of palatal miniscrews. Miniscrews placed in this area can aid in skeletal palatal expansion, intrusion of maxillary posterior teeth, and upper molar distalisation. The optimal insertion site is between the second premolar and the first molar with a 45° angulation to the palatal plane. This location could provide tricortical stabilisation (palatal vault cortical plate, nasal and maxillary sinus cortical plates) and application of a higher apical expansion force, thus improving biomechanical force application and potentially achieving better skeletal treatment effects (5,7) (Figure 1).

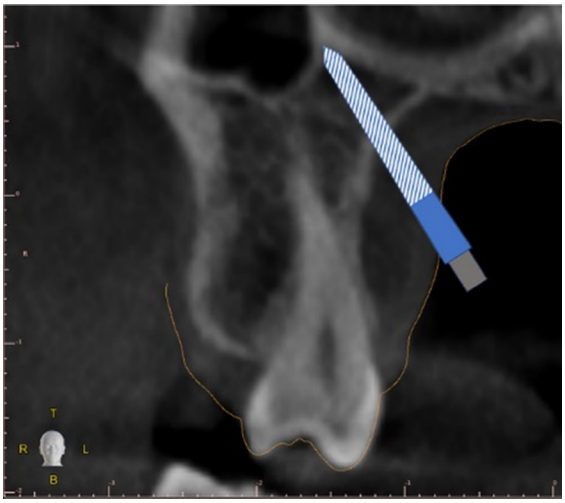

**Figure 1:** *Ideal miniscrew position in palatal posterior supra-alveolar insertion site to reach tricortical stabilization (7).*

— **Anterior area**

In the anterior region of the palate (distal surface of the first premolars), the optimal insertion site is 3 mm lateral to the midpalatal suture, from the palatal cortical to the nasal floor cortical at 30° (10). According to Nucera et al. (2022), both the third palatal ruga and 2 mm posterior to the third ruga (4 mm paramedian perpendicular to the palatal mucosa) could be the optimal insertion site for palatal miniscrew placement (14) (Figure 2, Figure 3).

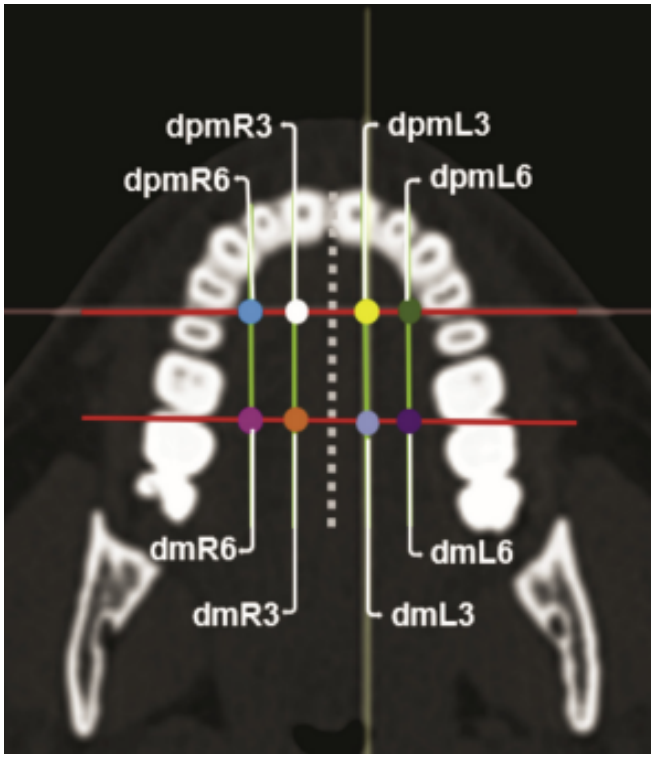


**Figure 2:** *Axial slice CBCT, reference points constructed to measure the palate thickness and the optimal mini-implant zone insertion, with distal face of the left first premolar at 3 mm from the midpalatal suture (dpmL3) (10).*

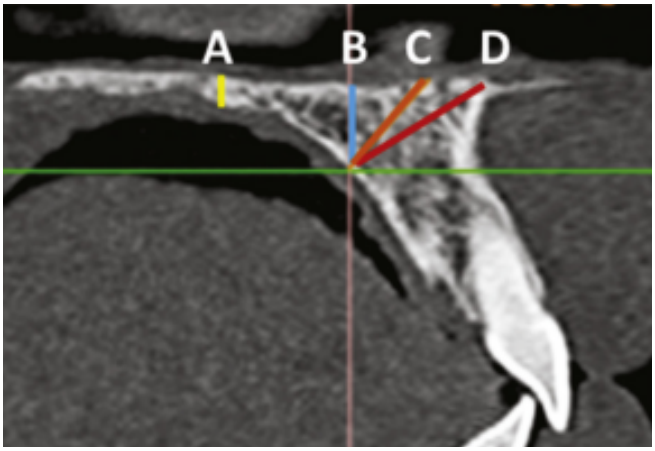


**Figure 3:** *Coronal slice CBCT, reference lines constructed to measure the palate thickness and the optimal mini-implant zone insertion. The D line is the measurement from the palatal cortical bone to the nasal floor cortical bone (30°) on dpmL3 point (10).*

**Mandibular Buccal shelf MBS miniscrew**:
The insertion site with optimal bone quantity is located regarding the buccal aspect of the distobuccal cusp of the 2nd molar, the preferred angle of insertion of the mini-implant is 30°–45° to the long axis of the tooth to engage maximum bone thickness and have adequate clearance from the tooth roots. Maximum bone thickness can be engaged by placing the miniscrew at a depth of 8-12 mm below the CEJ (15).

**Infrazygomatic miniscrew:**
The preferred site for placing the miniscrew is between the first and second molars, 4 mm away from the CEJ. The miniscrew size (2.0 × 12 mm) and insertion angle (60°) should be selected to allow for a deep enough bone insertion of the miniscrew to allow for bicortical fixation (16). According to Bingran et al., the miniscrew site is located between the first and the second upper molar at a height of 15 mm above the posterior occlusal plane, a gingival tipping angle of 60°-70° and a distal tipping angle of 30°. The appropriate miniscrew for this site is characterized by the following dimensions: 9-11 mm in length and 1.6-2.3 mm in diameter. From a clinical point of view, digital palpation allows the greatest prominence of the infrazygomatic crest for miniscrew insertion (17) (Figure 4).

## *Digital workflow for the production of miniscrew guides:*

Digital workflow is a process of acquiring digital images of the patient's dental arches, viewing and manipulating these images in specific computer-aided design (CAD) software and printing the files in 3D. In orthodontics, the placement of miniscrews

can be planned, based on 3D digital models and radiographs. The conception of a digital printed insertion guide is made following this protocol (18):

## Digital selection of the miniscrew insertion site:

**Acquisition of clinical data:**
The first step is to obtain 3D CBCT data of the area of interest. Then, information on the intraoral situation, including teeth, alveolar ridge, and soft tissues, can be acquired with an intraoral scanner or by using conventional digitized plaster casts (18). According to TOMITA et al. (2018) (19), intraoral scans can be more accurate than conventional impression/mold scans. File data from dental arch scans and from DICOM CBCT (Digital Imaging and Communications in Medicine) are exported as a universal STL files (stereolithography) (20, 21).

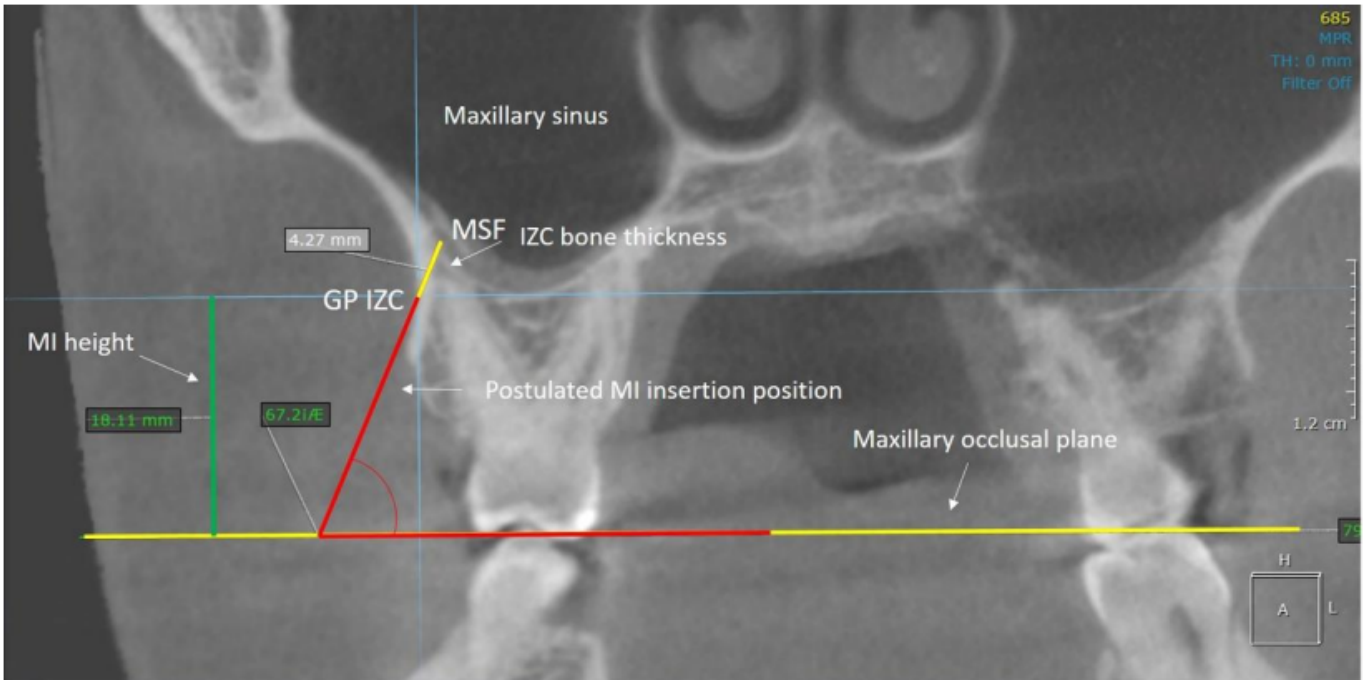


**Figure 4:** *Coronal slice, reference lines constructed to measure the infrazygomatic crest thickness and the mini-implant insertion angle and height according to Antelo et al. (2022) (17)*

**Using surgical planning CAD program software:**
Software tools for digital planning range from open source to proprietary solutions. The chosen software superimposes dental arches on the CBCT with intraoral scan. The CBCT provides alveolar and facial bone structures and dental roots data whereas the intraoral scan provides a high-quality dental arch surface data in the same 3D structure (18, 21).

Miniscrews 3D files, are available on some CAD software libraries, or can be digitally customized in the software using the "customize implant" function, dimensions are obtained from the manufacturer or by measuring or scanning the miniscrew to be used, the created miniscrew can be saved in the software library for future case planning (2, 23).

With virtual placement, the clinician can adjust the position and orientation of the screws in the axial, coronal, and sagittal views, as well as in the 3D reconstruction. The aim is ensuring sufficient bone support and a safety margin with the surrounding anatomical structures (2).

The CBCT-based digital planning of miniscrew-supported devices such as the maxillary skeletal expander (MSE) has the advantage of increasing the precision and safety of the procedure, considering both anatomical and biomechanical factors. In fact, this planning concerns both the body of the expander and the miniscrew that supports it. It allows choosing the orientation of the expander so that the force vector of the expansion is as close as possible to the centre of maxillary resistance, to allow parallel opening of the suture. It also allows choosing the length and the orientation of the miniscrews to ensure bicortical fixation (fixation in the cortical bone layers of both the palatal vault and the nasal floor), which optimises the stability of the miniscrews during the application of an orthopaedic force (2, 23, 24).

## Fabrication of the surgical guide:

The surgical guide is digitally designed in the software and exported in a STL format to a

professional 3D printer. When the device supported by miniscrews already exists, the device itself can be scanned, imported on the software, and used as a guide (20).

However, first inserting the mini-implants in a good bone sites according to digital planning using guides and then proceed with clinical data acquisition to design the intraoral device is more accurate (18, 25).

According to several studies that have evaluated the accuracy of surgical placement guides (4, 23, 26, 27) (Table 1) to reduce placement deviation, the design must meet certain criteria:

- The materials used should be non-flexible.
- The surgical guide should have adequate retention and stability so that the miniscrews are not dislodged by the insertion force during placement.
- Tooth-supported insertion guides, which rest on the edges of the teeth, ensure greater accuracy of insertion than mucosa-supported guides.

### Miniscrew placement

A clinical test to check the stability of the guide is necessary. After sterilisation the guide is stabilized by the occlusal force of the patient if it is a tooth-borne guide. The miniscrew is slowly inserted through the hole in the surgical guide until the body of the miniscrew is embedded in the alveolar bone as indicated by a marker on the tip of the screwdriver (23).

## DISCUSSION

Thanks to digital planning, we can reduce the failure rate of miniscrews and improve the accuracy of their placement (28) (Table 1). However, due to the amount of radiation exposure and the high cost with 3D techniques, using two-dimensional radiographs with a surgical guide for routine mini-implant placement is recommended (29).

## TABLE 1: RELEVANCE OF DIGITAL TECHNOLOGY IN THE ACCURACY OF MINISCREW PLACEMENT

| Miniscrew area | Author | Study design | Sample size | Objective | Intervention description | Digital method relevance |
|---|---|---|---|---|---|---|
| **Infrazygomatic crest** | Prajak Jariyapongpaiboon et al., 2020 (23) | Retrospective study | 20 subjects | Evaluate the accuracy of IZC miniscrew placement using a computer-aided design and manufacturing (CAD/CAM) surgical guide. | **Group DI** Direct insertion **Group SG** Insertion using CAD/CAM surgical guides | Most accurate miniscrew placement |
| | Li Su et al., 2022 (37) | Prospective cohort study | 17 subjects | Evaluate clinical effects of two kinds of templates, type A and type B | **Group C** Direct placement **Group A–B** Miniscrew placement is designed by type A or type B template EXOCAD software. | Better depth control in the insertion Avoiding injury to the maxillary sinus |
| **Anterior palate area** | Giorgio Iodice et al., 2022 (38) | Retrospective study | 35 subjects | Evaluate the differences between a planned insertion versus a direct method insertion. | **One group:** Comparison of direct insertion method planned insertion method by superimposing lateral cephalograms and plaster models of each patient. | Operating aid for clinicians with less experience |
| **Interradicular area** | Mi-Ju Bae et al., 2013 (39) | Prospective study | 12 cadaver maxillae | Evaluate the accuracy of miniscrew placement by using surgical guides developed with computer-aided design and manufacturing techniques | **control group** Direct insertion using 2D periapical radiographs **surgical guide group,** Placement with surgical guides based on cone-beam computed tomography (CBCT) | More accurate miniscrew placement |

***In the interradicular site:**
The two-dimensional intraoral radiograph of the interradicular area provides sufficient information for miniscrew placement. However, if miniscrew placement is difficult due to complex anatomy such as an expanded sinus or alveolar bone loss, using CBCT data for planning may be considered (29).

When placing miniscrew in the palatal or infrazygomatic site, using a surgical guide from the CBCT is interesting for more safety (Table 1).

***In the anterior palatal and paramedian area:**
The study by Jung B et al. (2011) found that 98% of bone assessments were reliable and sufficient with lateral radiography and the amount of bone was confirmed during the procedure of placing the miniscrew. The authors concluded that the bone volume in this site is favourable and the vertical bone dimension, as displayed on lateral cephalometry, reflects the minimum rather than the maximum bone height in the medial plane. Therefore, preoperative CT or CBCT is only indicated when lateral cephalometry reveals insufficient bone (30).

***In the mandibular buccal shelf zone (MBS)**
According to Natalia Escobar-Correa et al. (2021), MBS provides an optimal bone surface for miniscrew insertion, with optimal osseous characteristics for class III patients and patients with a low angle who exhibit the most favourable osseous characteristics in the MBS area (31). According to ETOO et al. (2023)the ideal site for BS miniscrew insertion is the distal root area of the second molars, regardless of facial pattern, gender, and age. In women, the buccal shelf has less bone thickness and height and less bone thickness and height than the inferior alveolar nerve canal (32). The buccal area of the first molar does not appear to show reduced values for appropriate bone width, according to Kolge et al. (2019). Nevertheless, insertion in this area can be achieved for an individual after assessing by 3D imaging or at least digital palpation showing that the patient has adequate bone (33). Arvind's trans mandibular (ATM) is a newly described radiographic technique that relies on the use of an intraoral radiographic film or radiovisiography (RVG), placed outside the patient's mouth along the lower mandibular border. The resulting radiograph shows the image in axial view along the first molar. This radiographic incidence allows to assess the postoperative buccolingual positioning of the buccal shelf implants in relation to the adjacent molars (34).

***In the infrazygomatic crest:**
The size of the miniscrew and the site of insertion depend on the bone thickness of the infrazygomatic ridge area, the morphology and thickness which vary according to the ethnicity of the patients. Tavares et al. (2020) found in their study that individual parameters (side, gender, vertical, and sagittal skeletal patterns) do not significantly influence the thickness of the infrazygomatic ridge (16), thus, mastering basic anatomical knowledge is also required. A 3D radiological evaluation would be useful to avoid perforation of the maxillary sinus during screw placement and to ensure its bicortical fixation (vestibular cortical plates and lateral wall of the maxillary sinus) (34).

***Limitations and implications for clinical practice and for further research**
Note that whereas CBCT provides accurate information for assessing alveolar bone height, it shows substantial errors assessing fenestrations and dehiscences. Caution must therefore be exercised when assessing these defects (36). Hence the need for large-scale studies to map miniscrew insertion in different regions, considering ethnic, gender and various anatomical characteristics.

## CONCLUSION

The digitally-assisted miniscrew insertion system is clinically proven and offers several advantages: it ensures reliable and precise miniscrew placement, avoiding contact with roots or delicate anatomical structures. However, digital workflows require collaboration with a specialized laboratory that has mastered this technology to minimize sources of error in the manufacturing process. This technique also requires the use of CBCT, which exposes the patient to additional radiation. Therefore, these techniques should be reserved for the most complex cases and will not be used routinely.

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LITERATURE REVIEW

# ACTINIC CHEILITIS ("SAILOR'S LIPS"): A REVIEW FOR THE CLINICIAN

## *QUEILITE ACTÍNICA ("LÁBIOS DE MARINHEIRO"): UMA REVISÃO PARA O CLÍNICO*

Maria Vitória de Matos[1], Julia Honorato[2], Ana Flávia Schueler de Assumpção Leite[3], Silvia Paula de Oliveira[4], Simone de Queiroz Chaves Lourenço[3]

## ABSTRACT

Actinic Cheilitis (AC), also known as "sailor's lips", is a premalignant pathology, and although it is easy to diagnose and prevent, late diagnosed cases may progress to lip carcinoma. Since its main etiological factor is exposure to ultraviolet rays, individuals often exposed to the sun, including military personnel, can be considered a risk group for the disease. The aim of this study was to describe the main risk and prognostic factors of AC and to create a clinical protocol for dental surgeons, making easier to identify and conduct each case. For this purpose, a search for articles relevant to the topic was carried out in Medline, Lilacs, SciELO and PubMed databases, from 1987 to 2022. The following AC patient profile was identified: male, in the fifth decade of life, fair skinned, with lesions on the lower lip and with a long history of outdoor occupational activities/intense sun exposure. The dentist has a fundamental role in identifying risk groups, early recognition of the disease and in more advanced cases, making the correct diagnosis and recommendation to specialized care.

**Keywords:** Actinic Keratoses, Lip Neoplasms, Precancerous Conditions, Squamous Cell Carcinoma, Solar Cheilitis

## RESUMO

A Queilite Actínica (QA), também conhecida como "lábios de marinheiro", é uma patologia com potencial de malignização e, ainda que seja de fácil diagnóstico e prevenção, casos diagnosticados tardiamente podem evoluir para carcinoma de lábios. Seu principal fator etiológico é a exposição aos raios ultravioletas, e por este motivo, indivíduos que se expõem muito ao sol, incluindo militares, podem ser considerados grupo de risco para a doença. O objetivo principal deste trabalho foi descrever os principais fatores de risco e prognósticos da QA e apresentar uma revisão para o cirurgião-dentista, facilitando a identificação e conduta. Para tal, foi realizada busca de artigos pertinentes ao tema nas bases de dados Medline, Lilacs, SciELO e PubMed, de 1987 a 2022. O seguinte perfil do paciente com QA foi identificado: homem, na quinta década de vida, pele clara, com lesões no lábio inferior e com histórico de longo tempo de atividades ocupacionais ao ar livre/intensa exposição solar. O cirurgião-dentista possui papel fundamental na identificação dos grupos de risco, no reconhecimento precoce da doença e, em casos mais avançados, realizar o diagnóstico e o correto encaminhamento para atendimento especializado.

**Palavras-chave:** Carcinoma de Células Escamosas, Ceratose Actínica, Lesões Pré-Cancerosas, Neoplasias Labiais

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## INTRODUCTION

Oral cavity cancer (OCC) is one of the most common cancers in Brazil. According to the National Cancer Institute of Brazil (INCA), the estimated number of new cases of CCO in the country, for each year of the three-year period from 2023 to 2025, is 15,100 cases, corresponding to an estimated risk of 6.99 per 100,000 inhabitants, being 10,900 in men and 4,200 in women (1). The labial location is one of the most common locations for OCC (1), and authors report that there are lesions that have a higher risk of malignancy and precede the appearance of OCC, the so-called "Potentially malignant oral disorders". Actinic cheilitis is included in this group (2-5).

The appearance of actinic cheilitis (AC), also known as "sailor's lips", is associated with sun exposure, but there are other associated factors that can contribute to its development, such as smoking and drinking alcohol (5,6). The intensity and time of exposure to the sun, physical characteristics, such as fair skin tone associated with occupational activities carried out outdoors, increase the chances of developing the disease (6,7).

The marine population, in this context, needs greater dentistry care mainly regarding stomatology assessment. The lips must always be checked, due to the great exposure of soldiers to outdoor tactical activities, for long periods and on a recurring basis, in addition to mandatory physical activity, so that they are excessively exposed to the harmful effects of the sun (8).

Current evidence on the actual rates of malignant transformation of AC is limited, mainly due to the few studies and different methodologies applied, showing that AC is clinically important, but a relatively neglected condition (9). The absence of symptoms leads many patients not to bother to investigate it and professionals, in turn, end up delaying the definitive diagnosis because they do not suspect the injury and treat it clinically as an inflammatory process (10).

The aim of this literature review was to describe the main risk factors and prognoses of AC, generating a review that facilitates the dentist's identification and clinical management, besides to promote prevention measures and guidance for risk groups.

## MATERIALS AND METHODS

To this review, a bibliographic search was carried out in the Medline, Lilacs, SciELO and PubMed databases. As inclusion criteria, articles published between 1987 and 2023, in English, Portuguese and Spanish, and which had an abstract available, were selected. The descriptors used were "actinic cheilitis" and/or "solar keratosis" and/or "sailor lips". After a first selection, according to the descriptors, the abstracts were read to define the relevance of the texts. Articles that did not address the topic and whose final version was unavailable for consultation were excluded. Herein, a total of 40 articles were included in this literature review.

## LITERATURE REVIEW

### *Epidemiology*

AC is an inflammatory condition of the lips, which appears directly associated with sun exposure. The classic demographic profile of patients at high risk of AC is men over 50 years of age, fair skin, and with a long period of sun exposure, with the lower lip being the most affected site (11–13).

### *Risk factors and prognostic for actinic cheilitis*

#### Sun Exposure

Historically, AC has been recognized as more prevalent in outdoor workers (farmers, fishermen and professions that are directly exposed to the sun), especially in hot and dry regions, due to its direct correlation with sun exposure (14,15). It is stated that the longer the exposure time, the greater the severity of AC in individuals exposed to ultraviolet radiation rays (UV) (16).

UV is, unquestionably, a factor related to AC (11,12), and the probability of malignancy may be higher when this exposure is associated with carcinogenic factors, such as alcohol and tobacco, becoming more pronounced in cigarette smokers due to the heat generated by burning tobacco and the absorption of its toxic products through the mucosa (11,17,18). Furthermore, there is increased susceptibility among patients with certain genetic disorders (e.g., xeroderma pigmentosum, albinism and porphyria cutanea tarda) and/or immunosuppression, and they should be alert to a possible progression to Squamous Cells Carcinoma (SCC) (19).

Inadequate use of photoprotection can make individuals more susceptible to the onset of AC. The use of a cap as a form of protection, and not a wide-brimmed hat, is only effective for the upper and middle third of the face, favoring the direct incidence of ultraviolet rays on the lips. Moreover, because they believe they are protected against radiation, individuals often disregard the importance of using sunscreen and lip balm (11,20).

### Anatomic site

Authors report that 95 to 100% of AC cases occur in the lower lip (11,12) due to its greater direct exposure to sunlight, when compared to the upper lip (14,21). Lips are highly susceptible to actinic keratosis and the harm caused by exposure to UV radiation because their protection mechanisms against radiation are reduced compared to the skin: thinner keratin thickness in the region, thin epithelial layer, little amount of melanin and decreased secretion of sebaceous and sweat glands (10,16,20).

### Sex, age, and skin color

Childhood is the most vulnerable phase to the effects of the sun, and excessive exposure during the first years of life increases the risk of cancer (1). The effects of radiation are cumulative, and the slow and asymptomatic progression of AC makes this injury being considered a normal condition of aging (22). The average age of diagnosis of AC is 40 years, but studies can be found that point to the fifth decade of life as the most common for diagnosis, due to the chronic nature of the disease (17,18,21).

Some studies show that women may be less likely to experience AC due to the use of lipstick, which may partially protect the lips from the sun, and the habit of using sunscreen and lip balm (17,23). On the other hand, the use of sunscreen is not frequent among males (24). In this sense, studies in specific populations, such as rural workers and fishermen, have shown a higher prevalence of cases in men, due to their occupation (16,21).

The different prevalence of cases between the sexes can still be explained by the fact that AC is normally an asymptomatic lesion and males take longer to seek dental treatment, generally showing less self-care, thus only fewer lesions end up being detected in their early stages. (21,25–27).

Individuals with fair skin color have a higher prevalence of injuries (24, 28). The absence of melanin predisposes to the appearance of lesions, as it plays a preponderant role in protecting against UV rays (28). The incidence of AC may be higher than expected in some darker-skinned individuals, but this is almost always related to high-risk occupational and recreational exposure (24).

A retrospective analysis carried out at the stomatology clinic of the Navy Dental Clinic of Brazil verified the prevalence of AC in 1,057 individuals treated at the institution, mainly in military personnel with continuous exposure to ultraviolet radiation. The study found 29 patients diagnosed with AC, with a predominance of males, Caucasians, with an average age over 40 years old and with lesions located on the upper lip. Such findings corroborate the pattern of clinical characteristics found in the patient with AC in the other studies analyzed (29).

### Education, income, and occupation

In the Brazilian population, men with low income and low education are generally more affected by AC. The higher prevalence in men is due to occupational exposure: men with low education and low income seek their livelihood in jobs that require greater resistance and physical vigor, including jobs that demand greater exposure to the sun and high temperatures (13, 25).

Occupation can contribute to the appearance and progression of injuries, as well as enabling individuals to develop habits such as smoking, alcohol consumption and chronic exposure to the sun (14). Occupations are those related to the outdoors, such as farmers, fishermen (14,15), sailors, farmers (19) and professions with direct exposure to the sun, especially in hot and dry regions (14,15).

### *Habits*

For some authors, the role of drinking alcohol and smoking is still controversial in the literature, both for the emergence of precancerous lesions and for SCC. However, it is known that lips are directly exposed to tobacco carcinogens and that the association of smoking with occupational exposure can contribute to the development of AC (12,32). Alcohol and tobacco predispose to the appearance of this pathology because of the heat generated by burning tobacco and the absorption by the mucosa of its toxic products (12,14,15).

It is known that, for the development of AC, there is a cumulative effect of different attacks over long periods (25). When analyzed separately, the habits “alcohol use” or “tobacco use” do not present significant correlations with the presence of AC (25,26). However, when these habits are evaluated together, “alcohol and tobacco use”, a significant association with the presence of the lesion can be verified (33). It is important to report that some studies indicate a positive association between the presence of AC and sports that require continuous exposure to the sun, such as in runners and cyclists (34).

### *Clinical appearance and histopathological alterations*

Intense sun exposure for a short period of time triggers an acute superficial inflammation of the lips, which is characterized by the presence of some elevations, dryness and swelling of the lower lip, without dysplastic changes in the epithelium though (13,33). When prolonged and high-intensity exposure to UV radiation occurs, changes occur that appear as multiple white areas, with zones of epithelial atrophy and erythema, thickening of the lip, loss of definition of the boundary between the skin and the semi-mucosa, eventually accompanied by fissures, scales and ulcers (13,18,33,34). Eventually, chronic ulceration may develop, lasting months and later progressing to SCC (18).

There is a gap regarding the classification of the AC stage at the time of diagnosis and the right time for intervention. Although the diagnosis is basically made based on clinical characteristics, biopsy must be indicated to exclude the possibility of malignant transformation (35).

To support the clinician in deciding whether or not to use an invasive therapeutic approach, several authors have been creating classifications for AC (14, 36). In 2017, a classification was created, which divides the evolution of the disease into 4 categories, based on AC descriptions made by classic and contemporary authors of the pathology (35).

The classification by Poitevin et al., 2017 (clinically represented in Figure 1) is presented as follows:

- Grade I: dryness and peeling of the red lips;
- Grade II: Atrophy at the vermilion border, presenting soft surfaces and pale areas with rashes. Beginning of loss of definition of the redness of the lip with the skin, or a dark line demarcating this limit can be seen;
- Grade III: Rough and scaly areas in the driest parts of the vermilion of the lip and hyperkeratotic areas, especially at the limit between the labial mucosa and semi-mucosa;
- Grade IV: Ulceration present in one or more locations on the vermilion of the lip or leukoplastic area, especially in locations more susceptible to trauma. Lesions may suggest progression to malignancy.

**Figure 1:** *Clinical photos of actinic cheilitis (AC) reference for applying the Poitevan classification, 2017 –* **A:** *AC grade I - fissure and desquamation;* **B:** *AC grade II - atrophy of the vermillion lip, leukoerythroplastic and brown color changes, shallow fissures and beginning to lose definition of the boundary between lip and skin;* **C:** *AC grade III - rough, dry and hyperkeratotic regions; and* **D:** *AC grade IV - change in color throughout the lip, deep fissures and swollen lip appearance, with a heterogeneous leukoerythroplastic lesion speckled on the right, suggestive of malignancy.*

It is important to highlight that, although there are classifications that facilitate therapeutic decisions, there are a variety of clinical presentations for the different degrees of AC. Therefore, initial clinical signs should not be ignored, since the presence of lesions that appear clinically homogeneous do not correlate with the degree of histological alteration (21, 24). Clinical findings alone should also not be considered as decisive factors for whether a biopsy should be indicated (37).

In cases in which AC is clinically harmless, conservative treatment is the most indicated, especially the use of lip sunscreen. Biopsy is indicated according to the clinical aspects of the disease and with the aim of monitoring the patient for possible malignant transformation of the lesion. After the biopsy, in cases of absence of epithelial dysplasia, conservative treatment can be applied, and the patient must be instructed to use adequate protection, in the form of lip sunscreen and a brimmed hat. However, patients in whom exposure to sunlight is continuous should undergo regular monitoring and more cautious care (35).

For better clinical management, it is necessary to carry out a clinical assessment (30), in which anamnesis must be applied, containing the clinical history of the injury, the clinical examination itself and the correct referral to the specialist, if necessary, to perform a biopsy with histopathological evaluation (35). In the flowchart presented in the Figure 2, it is possible to check the relevant points to be considered in the clinical assessment.

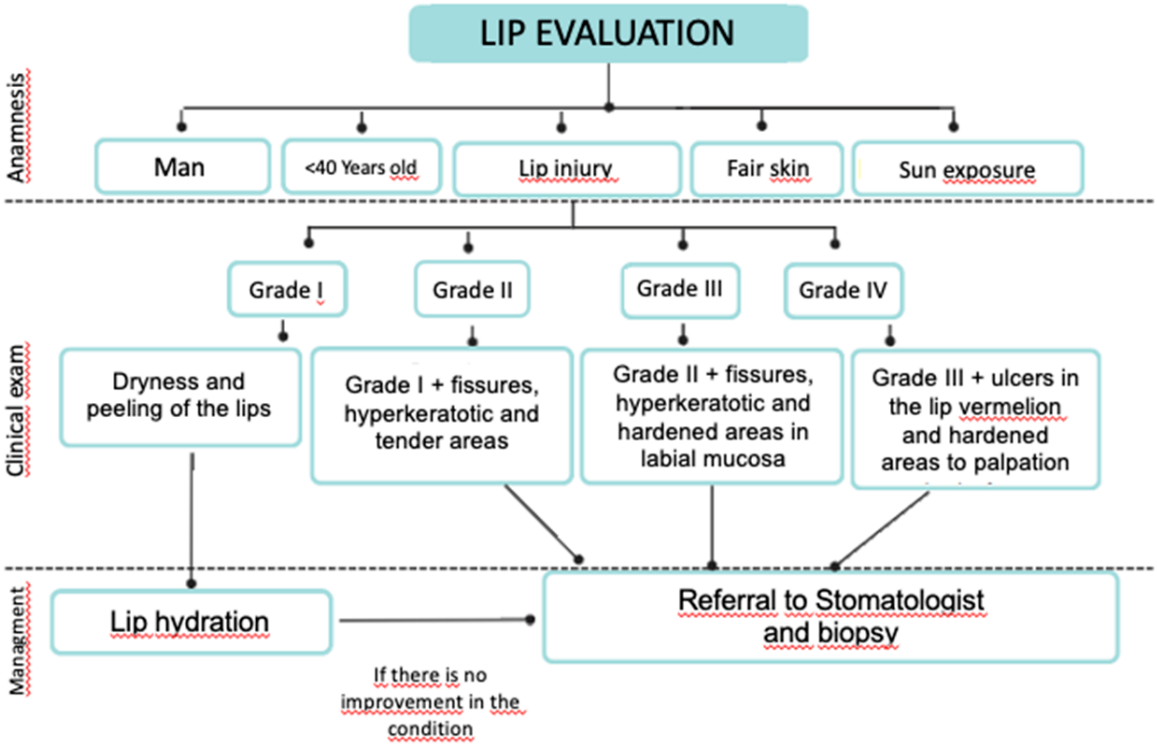


**Figure 2:** *Flowchart containing the relevant characteristics of the anamnesis that suggest the presence of AC, as well as the signs present in the clinical examination and management in each of these conditions. (Adapted by Poitevon et al., 2017).*

The prognosis of AC depends not only on histological characteristics, but also on the patient's change in habits, as well as their commitment to treatment (21). The exact rate of transition from AC to carcinoma is still unknown, however, it is known that AC more than doubles the patient's risk of developing SCC of the lip (19, 30).

## *Patient instructions*

Even though many of the changes associated with AC are irreversible, patients should be encouraged to reduce sun exposure, especially between 10 am and 2 pm, and 3 pm during daylight hours, wear a wide-brimmed hat and lip sunscreen to prevent further damage (19, 30). Still regarding the use of sunscreen, studies show that those who reapply sunscreen during exposure to the sun have a lower risk of developing the pathology (38).

Mild cases must be evaluated regularly to prevent malignant transformation of the lesion (35). In the early stages, without mild changes or dysplasia, treatment is the use of lip sunscreens. Thus, to prevent skin and lip cancer, patients should use sun protection factor 15 or greater,

requiring reapplication throughout the day (39, 40), in addition to remaining in the shade, wearing protective clothing and not use industrial tanning devices (39).

## CONCLUSION

Male individuals, with an average age of 40 years, with fair skin and who are constantly exposed to the sun, are considered a risk group for the development of AC. The clinical and histopathological characteristics of AC must be considered by the dentist to intervene as early as possible and exclude the possibility of a diagnosis of SCC of the lip. The use of individual photoprotection barriers and lip sunscreen are the most efficient way to prevent the onset of AC.

The authors declare no conflicts of interest.

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# THE IMPORTANCE OF METHODS FOR DETERMINATION OF SQUELETAL AND DENTAL AGE IN ORTHODONTICS AND PEDIATRIC DENTISTRY – A LITERATURE REVIEW

## *A IMPORTÂNCIA DOS MÉTODOS DE DETERMINAÇÃO DAS IDADES ESQUELÉTICA E DENTÁRIA NA ORTODONTIA E ODONTOPEDIATRIA – UMA REVISÃO DE LITERATURA*

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## ABSTRACT

The stage of human development is closely related to bone or dental maturity, being essential for the choice of treatment for dentofacial changes in children and adolescents by orthodontists and pediatric dentists. There are several biological indicators to determine an individual's maturation, such as chronological age and hormonal changes, but these indicators can suffer interference. Aiming at a more accurate determination of development and growth peaks, for a better diagnosis and treatment plan, several methods have been developed to determine skeletal age and dental age, these being the assessment of carpal maturation, the morphology of the cervical vertebrae, bone fusion of the spheno-occipital synchondrosis and the median palatal suture, as well as the stages of dental calcification. The evaluation of hand and wrist radiographs is the gold standard for predicting skeletal age, and its correlation with other methods is already evident. Therefore, it is possible to use the assessment of cervical vertebrae and dental ages by Nolla and Demirjian.

**Keywords:** Age Determination by Skeleton. Age Determination by Teeth. Carpal Bones. Cone-Beam Computed Tomography. Radiography, Dental.

## RESUMO

O estágio de desenvolvimento humano é intimamente relacionado à sua maturidade óssea ou dentária, sendo essencial para a escolha do tratamento de alterações dentofaciais em crianças e adolescentes por ortodontistas e odontopediatras. Existem diversos indicadores biológicos para determinar a maturação do indivíduo, como a idade cronológica e as alterações hormonais, porém esses indicadores podem sofrer interferências. Visando uma determinação de desenvolvimento e dos picos de crescimento mais precisa, para um melhor diagnóstico e plano de tratamento, foram desenvolvidos diversos métodos para determinar a idade esquelética e a idade dentária, sendo estes a avaliação da maturação carpal, da morfologia das vértebras cervicais, da fusão óssea da sincondrose esfeno-occipital e da sutura palatina mediana, bem como dos estágios da calcificação dentária. A avaliação das radiografias de mão e punho é o padrão ouro da predição da idade esquelética, e sua correlação com outros métodos já é evidente. Sendo assim, é possível utilizar a avaliação das vértebras cervicais e das idades dentárias de Nolla e Demirjian.

**Palavras-chave:** Determinação da Idade pelo Esqueleto. Determinação da Idade pelos Dentes. Ossos do Carpo. Tomografia Computadorizada de Feixe Cônico. Radiografia Dentária.

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## INTRODUCTION

Chronological age is not the most reliable indicator for predicting human development, as it can be influenced by genetic, racial, environmental, nutritional, hormonal, and sexual factors, often not coinciding with physiological age, which is extremely important for diagnosis, treatment planning and prognosis, mainly in Pediatric Dentistry and Orthodontics. There are several biological ages, for example: bone age, morphological age, menarche age and dental age, which have been proposed to determine physiological age (1).

In Dentistry, determining physiological maturation is essential for evaluating the need and ideal time for orthodontic treatment, as each person has a biological clock, which regulates the time needed to reach the adult state, with maturity being the product of a process (two). During this maturation process, development stages occur at different speeds that follow the general growth trend of the body, occurring, more markedly, in the first decades of life, with decreasing speed – except for two accelerated phases, called growth peaks. The first period occurs during childhood, usually 6 to 8 years of age, and is called a childhood growth spurt. The second peak occurs during puberty, which is more pronounced and evident, the so-called pubertal growth spurt (PCS), which is most useful for the orthopedic treatment of bone dysplasias (3).

Through the precise determination of the PCS, it is possible to evaluate the peak growth velocity of each person, whether imminent, present, or complete (4). This point is fundamental for determining orthodontic treatments related to malocclusions caused by craniofacial skeletal changes, as it is possible to obtain the best results in a relatively shorter period, due to the direct relationship between the growth peak during puberty and the maxillo-mandibular dimensions. (5). Furthermore, it assists in the diagnosis, planning and early treatment of anomalies, as the prognosis of orthodontic therapy is directly related to the individual's growth and physiological maturation (6).

Given this context, this study aims to review the literature on the mentioned methods, in order to contribute as another means of information and resource in the diagnosis and planning of clinical cases in Pediatric Dentistry and Orthodontics. Herein, it serves as a tool to facilitate routine guidance for patients.

## LITERATURE REVIEW

The scientific literature was reviewed in the electronic databases PubMed and Google Scholar in September 2023. The combinations of terms included were: "Age Determination by Skeleton" or "Age Determination by Teeth". Articles that used any of the skeletal age prediction methods were included - suggested by Greulich and Pyle (7), Lamparski (8), Hassel and Farman (9), Baccetti (10), Bassed (11) and Angelieri (12) – or dental – suggested by Nolla (13) and Demirjian (14). There was no date restriction. Review articles, letters, editorials, and articles with forensic and/or criminal objectives were excluded. Additionally, only articles in Portuguese and English were selected, and those that did not present human samples, or that the evaluation had been carried out on syndromic patients or those with a disease were excluded.

After searching for articles in the databases, the title and summary were read, and the selection criteria were applied. Then, the chosen articles were read in full, excluding those that were not found in their complete version or did not present the proposed theme.

### *Skeletal age analysis*

Although growth spurts are generally present in every healthy population, these phenomena do not occur at the same chronological age for everyone, because they can be influenced by several factors, such as: genetic, socioeconomic, nutritional, among others. Thus, one of the most used ways to observe the growth and physiological maturation of individuals is the analysis of skeletal age (3). According to Greulich and Pyle, the skeleton provides a more useful measure of the individual's level of general maturity and can be used from birth until complete bone development (7).

Various parts of the human body can be used to determine skeletal growth through bone morphology and size. One of the most used and researched methods is the evaluation of hand and wrist radiographs, due to the ease of the radiographic technique and the reduced amount of radiation to which the individual is exposed, but, mainly, because of a large number of ossifications in a relatively small area (7,15).

Carpal radiographs have been used to analyze bone development since 1896, and since then, several assessment methods of this type have been created. Greulich and Pyle created an atlas using the sequence of the ossification centers of bone maturation of the hand and wrist. To carry this study out, a sample of 100 American children was used, from birth to 18 years old for females, and up to 19 years old for males. The authors created a pattern by dividing them into certain chronological ages, correlating with the greatest

possible coincidence of mineralization centers, anatomical shape, dimensions, and developmental stages of the epiphyses, being divided by male and female sex. The method therefore consists of comparing the carpal radiograph of the individual to be analyzed with the standard defined in the Greulich and Pyle Atlas (7).

To verify the clinical applicability of the Greulich and Pyle Atlas, Koch *et al*. analyzed 225 Turkish boys between 7 and 17 years of age. The authors found that skeletal ages were below the average chronological age in the period from 7 to 13 years of age, and advanced in the period from 14 to 17 years of age. Based on these findings, the authors concluded that Turkish boys have different bone maturation times compared to those studied by the Greulich and Pyle Atlas, which should be applied to this population with a correction factor (17). Other authors have also evaluated Greulich and Pyle's method in different ways. There are those who concluded that the Sauvegrain method is more accurate when compared to the Greulich and Pyle method, however, this finding appears in a study that presents a methodological deficiency regarding the comparison, which is carried out in a single moment (18). The Sauvegrain method uses radiographs in lateral and anteroposterior views of the elbow that evaluate the degree of maturation of some bones and correlate with the estimated bone age. Another manuscript, which reported research with a Taiwanese population, demonstrated inaccuracy in the Greulich and Pyle method (19).

On the other hand, another study also with a Taiwanese population showed that with adjustments to adapt to the studied population and considering that the Greulich and Pyle method takes less time and covers a wider age range, which was chosen as the most useful method clinic (20). From this perspective, there is a report of no significant difference between bone age and chronological age when using the Greulich and Pyle method (21). There is also a study that concluded that the Greulich and Pyle method appeared to be reasonably reproducible for assessing skeletal age (22). Besides, Koc *et al*. showed that the use of automated tools for estimating bone age with the Greulich and Pyle method can reduce interobserver variability and increase prediction accuracy (23). Booz *et al*. stated that artificial intelligence could improve the efficiency of clinical routine without compromising accuracy (24).

Even though the evaluation of carpal radiographs may be a widely accepted method, there is a tendency to use other methods of analyzing skeletal maturation, thus seeking to provide alternatives for professionals and, mainly, to reduce the ionizing radiation to which individuals are exposed because, despite the low dose, it constitutes an additional exposure (3). Hence, there are methods in which the cervical vertebrae are used to analyze skeletal age, since the lateral cephalometric x-ray is a determination exam in the diagnosis and orthodontic planning protocol. Currently, there is also a growing demand for cone beam computed tomography (CBCT), which provides three-dimensional analysis, especially in cases of impacted teeth, skeletal dysplasias and severe asymmetries, enabling a more accurate diagnosis and treatment plan. This fact stimulated the search for skeletal assessment methods visible in these exams, which could thus replace hand and wrist radiography (25).

Analysis of cervical vertebrae is associated with changes in size and shape during vertebral growth during adolescence. According to the study by García-Fernandez *et al*., the analysis of cervical vertebrae to determine the state of bone maturation began in the 1970s, when Lamparski observed the morphological changes in these structures, classifying them into six stages and establishing a subsequent comparison with the skeletal changes seen in the hand and wrist region, concluding that the cervical vertebrae are also effective in predicting bone age (8,26). In 1995, Hassel and Farman improved the method studied by Lamparski with the analysis of morphological changes occurring only in the second to fourth cervical vertebrae (C2, C3 and C4), classifying them into six cervical vertebra maturity indices (CVMI) and determining the remaining PCS (9).

Several other authors also found a high correlation between the maturation of cervical vertebrae and skeletal maturation, which is considered in the literature as a reliable method with easy clinical applicability (27-32), but there is still a certain reluctance among dental surgeons to replace the use of hand and wrist x-rays, despite the cost and additional radiation for the patient (33).

Considering the analysis of the maturation of cervical vertebrae, the method developed by Baccetti *et al*. stands out, who presented a new version of the method (10). They carried out an annual measurement of the mandibular dimension of 214 individuals and analyzed the inferior concavity of the C2, C3 and C4 cervical vertebrae (Chart 1). The assessment of concavities was divided into six stages. In stage 3, all presented concavity at the lower edge. The authors found

that the appearance of the concavity in C3, which occurs between stages 2 and 3, can be correlated to the pre-peak of mandibular growth (34).

## CHART 1 – DESCRIPTIVE CHART OF THE MATURATION STAGES OF THE C2, C3 AND C4 CERVICAL VERTEBRAE ACCORDING TO BACCETTI *ET AL*., 2002; BACCETTI *ET AL*., 2005 (22,23).

| | |
|---|---|
| Stage CS1 | The lower edges of C2, C3 and C4 are flat.<br>The bodies of C3 and C4 have trapezoidal morphology.<br>The peak of the mandibular growth spurt will occur, on average, two years after this stage. |
| Stage CS2 | The lower edge of C2 has a concavity.<br>The bodies of C3 and C4 have trapezoidal morphology.<br>The peak of the mandibular growth spurt will occur, on average, one year after this stage. |
| Stage CS3 | The lower edges of C2 and C3 are concavity.<br>The bodies of C3 and C4 can have trapezoidal or horizontal rectangular morphology.<br>The peak of the mandibular growth spurt will occur during the year after this stage. |
| Stage CS4 | The lower edges of C2, C3 and C4 are concavity.<br>The bodies of C3 and C4 have horizontal rectangular morphology.<br>The peak of the mandibular growth spurt occurs one to two years before this stage. |
| Stage CS5 | The lower edges of C2, C3 and C4 are concavity.<br>At least one of the bodies of C3 and C4 has a quadrangular morphology. If it is not square, the body of the other vertebra remains with a horizontal rectangular morphology.<br>The peak of the mandibular growth spurt stops at least one year before this stage. |
| Stage CS6 | The lower edges of C2, C3 and C4 are concavity.<br>At least one of the bodies of C3 and C4 has a vertical rectangular morphology. If it is not vertically rectangular, the body of the other vertebra is quadrangular.<br>The peak of the mandibular growth spurt ends at least two years before this stage. |

The methods for assessing skeletal maturation have a strong correlation with each other (35). There are studies that have correlated chronological age with skeletal age. One of them showed that there was a high correlation in Yemeni children (36). In the study by Magat and Ozcan, all correlations between dental and skeletal stages were statistically significant (37), and there are already proposals for artificial intelligence models to evaluate CVMI in cephalometric radiographs (38).

Another way of assessing skeletal age that can be used by the dentist is the observation of late fusion of the spheno-occipital synchondrosis (SOS), which is one of the most significant growth centers at the base of the skull, with a fundamental role in the development of the maxillo-mandibular complex (1). Scheuer and Black stated that the SOS shutdown almost certainly occurs during adolescence. They also added that the fusion times of intra-occipital and SOS are related to significant maturational events (39). Bassed *et al*. proposed a method for evaluating SOS in which five stages of ossification are defined, which begin with SOS without fusion, passing through the successor stages, which present the progression of ossification, until the complete obliteration of SOS, as shown in Chart 2 (11).

## CHART 2 – DESCRIPTIVE CHART OF THE MATURATION STAGES OF SPHENO-OCCIPITAL SYNCHONDROSIS (SOS) ACCORDING TO BASSED *ET AL*., 2010 (26).

| | |
|---|---|
| Stage 1 | SOS is completely open and unmerged. |
| Stage 2 | The top edge of the SOS is merged. |
| Stage 3 | Half of the length of the SOS is merged. |
| Stage 4 | SOS is almost all merged, but one site is still visible. |
| Stage 5 | The site is completely obliterated, presenting the appearance of normal bone. |

Delayed fusion of the midpalatal suture can also be used to determine the patient's stage of bone maturation. The classification is made through analysis of the CBCT examination or occlusal radiography, as both allow visualization of the general anteroposterior characteristics of the suture, without overlapping other anatomical structures. This method can provide reliable parameters for planning therapeutic approaches (40).

In 2013, Angelieri *et al*. (12) developed a study based on the morphology of the median palatal suture under observation during growth. For this purpose, CBCT images of 140 individuals were examined to define the radiographic stages of maturation of the midpalatal suture, establishing a scale of five stages of maturation of the midpalatal suture, which were identified and defined as shown in Chart 3.

## CHART 3 – DESCRIPTIVE CHART OF THE STAGES OF OSSIFICATION OF THE MEDIAN PALATAL SUTURE ACCORDING TO ANGELIERI ET AL., 2013 (28).

| | |
|---|---|
| Stage A | The midpalatal suture is almost a straight high-density line with no interdigitation. |
| Stage B | The midpalatal suture takes on an irregular shape, and a high-density stepped line appears. |
| Stage C | The median palatal suture appears as two parallel, stepped, high-density lines that are joined to each other, but separated by small, low-density spaces in the maxillary and palatine bones (between the incisive foramen and the palato-maxillary and posterior suture). the palato-maxillary suture). |
| Stage D | The suture may be arranged in a straight or irregular pattern. |
| Stage E | Fusion of the median palatal suture occurs in the palatal bone, with progressive maturation from posterior to anterior. |

### Dental age x growth prediction

Because of the need for more practical methodologies for predicting physiological maturation, dental age has also been intensely studied as it is a data easy to obtain and evaluate during routine dental treatment (41). Furthermore, dental mineralization follows a relatively constant developmental sequence and is more reproducible when checking chronological age (6). Correlations between the stages of dental calcification and skeletal maturity have been described, which allows, in a more practical way, the identification of the individual's stage of physiological maturation based on panoramic radiography, an exam commonly requested by professionals (41).

The development of carpal bones and teeth is correlated, according to Marshall, and it was highlighted that both can be used to represent physiological development, as they occur simultaneously (42). Chertkow and Fatti investigated the relationship between the mineralization stages of various teeth and hand and wrist ossification in a sample of 140 individuals. They concluded that the relationship between the lower second permanent molar and the calcification of the sesamoid adductor bone was low, with females developing earlier compared to males. They also noticed that men's dental development tends to be faster than bone, when compared to women's (4).

Dental mineralization has been the most appropriate method for estimating chronological age, according to Ferreira Júnior *et al* (43). The authors stated that women tend to be precocious. In the study, they found that homologous teeth, in the same arch, undergo the mineralization process together and the differences between them are statistically insignificant for all individuals. They also observed that at 6 years of age, girls show more accelerated mineralization than boys for the lower first and second molars (43).

The Nolla method is world-renowned and was developed with the purpose of studying the development of permanent teeth. To this purpose, annual panoramic radiographs were taken of 50 children between 55.3 and 201.8 months of age and analyzed, with a schematic drawing created dividing dental calcification into 10 phases, from the beginning of crown formation until apical closure. The application of this method is based on assigning a degree of mineralization to each of the permanent teeth in a quadrant, which corresponds to a development stage value. The sum of the values for each tooth is compared with the standard values that appear in the maturation tables and correspond to the average chronological ages, separated for each sex. In conclusion, tooth development is similar, and no differences were observed between females and males (13) (Chart 4).

## CHART 4 – DESCRIPTIVE CHART OF THE STAGES OF DENTAL CALCIFICATION ACCORDING TO NOLLA, 1960 (32).

| | |
|---|---|
| Stage 0 | Absence of dental crypt. |
| Stage 1 | Presence of a dental crypt. |
| Stage 2 | Beginning of tooth calcification (crown). |
| Stage 3 | Formation of one third of the dental crown. |
| Stage 4 | Formation of two thirds of the dental crown. |
| Stage 5 | Almost complete formation of the dental crown. |
| Stage 6 | Complete formation of the dental crown. |
| Stage 7 | Formation of one third of the tooth root. |
| Stage 8 | Formation of two thirds of the tooth root. |
| Stage 9 | Almost complete root formation, but with its apex open. |
| Stage 10 | Root apex closure. |

Dental development is one of the most real indicators of chronological age, according to Bolaños *et al*., who researched the best tooth to estimate chronological age, using the Nolla method. The sample used was 374 panoramic radiographs, 195 of which were male and 179 females. The authors concluded that for females under 10 years of age the best predilections for chronological age were the upper central incisor,

the first and second lower molar, while for males, they were teeth the upper central incisor, the lower canine and the lower first molar (44).

In 1999, a study by Rossi *et al*. evaluated the correlation between the stages of root mineralization of lower second permanent molars and calcification of the first finger. They used a sample of 71 female children, aged 8 to 13 years, and took intraoral x-rays and x-rays of the thumb on the left side on the same day. From the results, the authors found that most children were in Nolla stages 6 and 7 did not yet have the sesamoid bone. They highlighted, thus, that bone maturation is one of the most useful tools for analyzing development and that dental age can be determined through erupted teeth or by analyzing tooth formation on intraoral radiographs (45).

Dental age can also be analyzed by applying the Demirjian method, based on the mineralization of the seven left mandibular teeth. This method is based on a dental age scoring system that uses objective criteria and relative values rather than absolute lengths. Shortened or lengthened projections of developing teeth do not affect the reliability of the assessment. Identified by letters from A to H, the stages comprise the process of tooth mineralization from the crown to the apical closure. The application is based on assigning a value to each tooth, according to its degree of mineralization and according to the sex of the individual analyzed. The sum of these values is on a scale from 0 to 100, in which the values will be compared to pre-established values, resulting in correspondence to the individual's chronological age (14) (Chart 5).

Studies that compared dental age prediction methods were also carried out and a strong correlation was found between chronological and dental age (46). One study chose Nolla's method as the most reliable, followed by Willems and, the least reliable, Demirjian (47). Although the Demirjian and Willems methods showed a high correlation, the second was considered the most appropriate in another study (48). For Barati *et al*., the Willems method is also preferred (49). Demirjian's method has been questioned regarding the degree of prediction when the sample is treated as homogeneous and segmented by age and sex groups (50), also regarding the variability of ethnic groups (51). For children in southern Saudi Arabia, for example, Nolla's method was effective (52). Contrastingly, Marrero-Ramos *et al*. showed that Demirjian's method is reliable for estimating a person's oldest age (18 years) (53), and efficient for predicting skeletal maturity when comparing dental calcifications in Korean children (54). There is a suggestion that the Demirjian method may be a valuable tool for estimating age through the mineralization of third molars (55). By estimating dental age using the Demirjian method, it is possible to predict the degree of maturity, providing the choice of the ideal moment to start orthodontic treatment (56). Finally, research showed that the automated method outperformed the classical approaches tested (Demirjian and Willems methods) (57).

## CHART 5 – DESCRIPTIVE CHART OF THE STAGES OF DENTAL CALCIFICATION ACCORDING TO DEMIRJIAN *ET AL*., 1973 (14).

| | |
|---|---|
| Stage A | Beginning of calcification in the upper portion of the crypt, in the shape of a cone or inverted cones, without fusion between the points of calcification. |
| Stage B | Fusion of calcification points, formation of cusps and delimitation of the occlusal surface. |
| Stage C | Complete formation of occlusal enamel, beginning of cervical extension, deposition of dentin in the upper portion and beginning of the contour of the pulp chamber. |
| Stage D | Crown almost complete before the cementoenamel junction, roof of the pulp chamber well defined. |
| Stage E | More defined walls of the pulp chamber, root size smaller than the height of the crown for posterior teeth, marked presence of pulp horns and beginning of root bi- or trifurcation. |
| Stage F | Pulp chamber walls forming an isosceles triangle, root size similar to or slightly larger than crown height; In the furcation region of the posterior teeth, the calcification has a semilunar shape, and the canals are wide, with walls ending in a bevel. |
| Stage G | Canal walls parallel and apex partially open. |
| Stage H | Closed apex and uniform periodontal space around the root and apex. |

## CONCLUSION

Based on this review, the controversy surrounding methods for predicting skeletal and dental ages is evident, sometimes exposing some methodological deficiencies and the heterogeneity of results when evaluating different ethnic groups. However, the evaluation of hand and wrist radiographs is the most studied and most referenced, and its correlation with other methods has already been established. Hence, it is possible to use the assessment of the cervical vertebrae and dental ages of Nolla and Demirjian. The importance of such methods is unquestionable, whether just because they predict age, or because they make it possible to correlate two assessments, but mainly from the perspective of applying the different methods of assessing skeletal and dental age as diagnostic and planning resources in guiding clinical cases in Pediatric Dentistry and Orthodontics.

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