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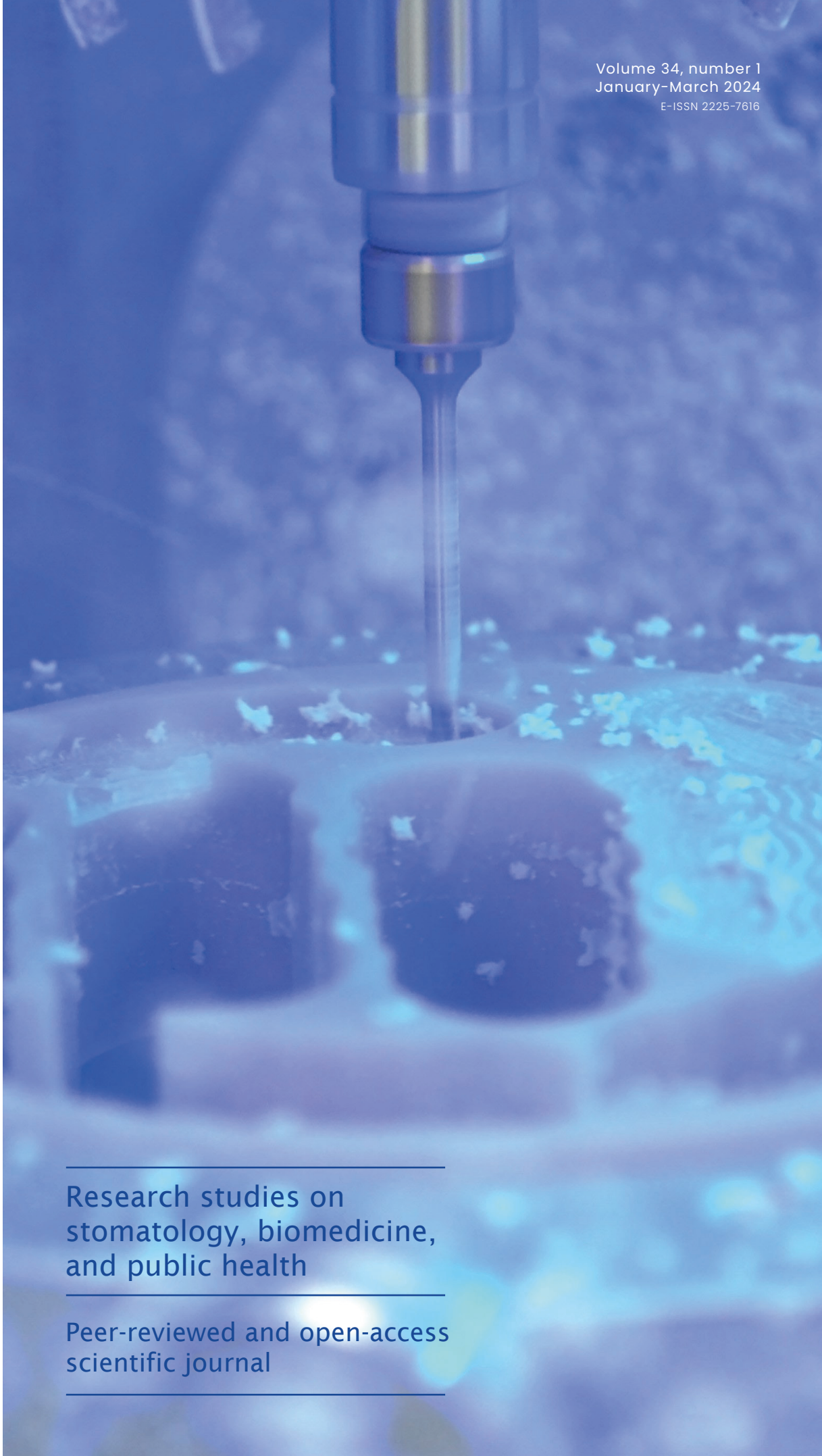

Research studies on stomatology, biomedicine, and public health

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EDITORIAL

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Carlos Mendiola-Aquino
Vice-Dean of the Facultad de Estomatología of Universidad Peruana Cayetano Heredia

Strengthening evidence-based management

Carlos Mendiola-Aquino, MSc.[1]

The authorities of Universidad Peruana Cayetano Heredia (UPCH) are currently developing a Strategic Plan towards 2050. The purpose of this plan is to set long-term objectives that define a common goal, regardless of those who lead the institution. The implementation of prospective plans will enhance research, innovation, and technology transfer.

Within this strategic plan, the Facultad de Estomatología proposes, as one of its goals, to strengthen its social responsibility activities and establish a more active connection with society. In the middle of this challenge, we think of the words of our founder, Dr. Roberto Beltrán: "The next step is to intensify health promotion and mouth disease prevention, especially for the benefit of the low-income population." Similarly, our focus is to prepare our students to take optimal advantage of the significant investments made in the acquisition of equipment that has transformed the academic training processes. The simulation strategy, integrated into the educational model a few years ago, enables our students to acquire in advance the necessary skills to guarantee academic excellence in the performance of clinical care. Haptic simulators, phantoms, and the recent remodeling of the multifunctional laboratory in the venue of San Martín de Porres are concrete examples of the investments made to benefit our students, patients and teachers. These initiatives reflect our commitment to continuous improvement and quality education in stomatology.

Transfer of knowledge through research, development and innovation (R&D&I) is an invaluable source that benefits our society as it provides answers to problems that need to be addressed. To this end, investment in research is vital and it is a characteristic sign of the Facultad de Estomatología, which goes hand in hand with the growth of the country. In the Peruvian context, R&D&I funding remains a constant challenge, falling behind the other countries in the region. In that sense, the urgent need to increase these resources for the development of the community is emphasized. Despite the difficulties in the scientific community such as the lack of infrastructure and limited connection with the private sector, there is a way to go through and have success. In this context, Peru is home to an extensive network of entities dedicated to R&D&I, as well as qualified scientists who, with

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the right resources, could become crucial drivers of the country's progress.

In the context of the Facultad de Estomatología of UPCH, initiatives to promote R&D&I are based on the strengthening of its research teams and evidence-based management. The generation of knowledge is intrinsically linked to the effective implementation of relevant research management strategies. This includes the consolidation of research groups in areas such as dental materials, biochemistry in oral health, oral-maxillofacial pathology, public health, and stomatological management, apart from resuming research lines such as dental education with emphasis on the areas of simulation and digital transformation. Moreover, it is essential to recognize the importance of generating appropriate environments for collaboration such as interdisciplinary laboratories and multicenter research studies.

This implies an allocation of resources for infrastructure, equipment, investment in research, information technologies, and funding of scientific publications. To effectively support these proposals and achieve scientific excellence, it is essential to establish a strong research culture.

Within this framework, it is necessary to focus on strategies that, as an institution, allow us to adapt and respond to the constantly changing problems and needs of the population. For this reason, by incorporating generational change in the teaching staff as an integral part of our management model, we aim to identify and strengthen the leaders of tomorrow, thus forging talents capable of playing essential roles. This task can only be achieved by synchronizing previous experiences and new emerging perspectives. It is essential to mention that this approach does not compromise written history and does not threaten the roots and fundamental values that identify us. On the contrary, it seeks to promote a culture of learning and development in the faculty based on the experience of great professionals that this university has had. This momentum will inspire innovation and reinforce our commitment to the new generation of teachers and researchers who respond to our country's expectations, with the participation of our students who are UPCH's priority, guaranteeing the sustainability and permanent development of our institution.

ORIGINAL ARTICLE

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Comparison of the microhardness of composite resin with conventional and modified index techniques with printed cuvette into two light-curing times

Alfonso Napoleón Santos-Busso[1, a], *Lucia Elena Larios-Quijada*[2, a], *Raúl Hernández-Espino*[3, a, b], *Gustavo Augusto Huertas Mogollon*[1, a, c]

ABSTRACT

Objective: To compare the microhardness of composite resin with conventional and modified index techniques with a printed tray in two light cures. **Materials and methods:** There were six study groups according to the technique and the number of photopolymerizations: direct technique with one photopolymerization (D1P), direct with two photopolymerizations (D2P), conventional index with one photopolymerization (CI1P), conventional index with two photopolymerizations (CI2P), modified index with one photopolymerization (MI1P), modified index with two photopolymerizations (MI2P). Fifteen samples were used for each group. The samples had dimensions of 2 mm in height by 5 mm in diameter. The photopolymerization was performed following the indications of the group to which it corresponds and then subjected to the Vickers hardness test with three indentations on each side with a load of 200 g for 15 seconds. Two microhardness recordings were made, one superficial and the other at 2 mm. **Results:** There is a significant difference between the first light-curing surface microhardness groups ($p < 0.001$), and there is also a significant difference between the first light-curing 2 mm microhardness groups ($p < 0.001$). Likewise, there are no significant differences between the second light-curing surface microhardness groups ($p = 0.519$) or the second light-curing 2 mm microhardness groups ($p = 0.279$). **Conclusions:** There are no significant differences in surface microhardness and microhardness at 2 mm depth with conventional and modified index techniques in printed trays in two photopolymerizations.

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Keywords: hardness, composite resins, *in vitro* technique, dentistry.

INTRODUCTION

The stamp and injection resin technique is used for provisional and definitive restorations (1). Several articles refer to the index technique for different treatments using printed templates as part of the planning with digital design, finding optimal and satisfactory results when applying these restorations in patients. In this way, what we know as digital flow in dentistry is carried out, and it allows the reduction of working time and greater accuracy in the treatments followed. The index technique is about placing the resin on the tooth surface and, with the help of a transparent silicone matrix, perform the restoration directly on the tooth (2-7). In several articles, thickness modification of the silicone's matrix of the index technique (8-13) has been found due to the penetration of light that causes the photopolymerization of the resin.

Technological advances in dentistry have led to changes in restoration techniques over time, always in search of an optimal treatment for success. These technological advances involve the use of digital dentistry and the assistance of a design software, complemented, in some cases, with printers. Apart from that, the use of the new restoration techniques will also depend on the experience and training of the professional (14-19).

Treatments with modern technologies require the training of the dentist. Different articles provide information on restoration protocols; however, they all mention that the instructions given by manufacturers of the materials to be used shall be respected. It is important to mention that each article proposes a variation in the technique with conventional transparent silicone matrix, also called index, and the main variation is the one applied to the size of the silicone matrix, since the distance between the light-curing lamp and the resin is a factor that influences the light-curing of the resin; however, this could be compensated by a longer light-curing time (2-7).

Technological advances are reflected in resins since they currently have better physical and chemical properties. Microhybrid resins help to withstand high stresses due to their different particle size and composition (13-15), and permit better aesthetic management at the time of restoration, without losing their mechanical properties. Microhardness tests are the most widely used to measure mechanical properties of varied materials, as they can detect the ability of a body to resist being scratched (or also defined as its resistance to being indented) (19). In numerous studies on microhardness of polymerized composite resins, reference is made to the fact that greater microhardness was found on the upper face of the resin than on the lower face, varying according to the distance at which the light emitting unit is placed to allow it to photopolymerize (19-25). In this line, resins are resistant to loading and abrasion, and their values increase when the light-emitting source is closer to the resin, which is something positive (25-32).

The objective of this study was to determine if there are significant differences in the microhardness of the composite resin with conventional and modified index technique with tray printed in one and two photopolymerizations.

MATERIALS AND METHODS

The methodology used in this research was relational, with a quantitative, experimental, cross-sectional, and prospective approach.

The following groups were used to conduct this study:

- Direct technique with one photopolymerization (D1P)
- Direct technique with two photopolymerizations (D2P)
- Conventional index technique with one photopolymerization (CI1P)
- Conventional index technique with two photopolymerizations (CI2P)
- Modified index technique with one photopolymerization (MI1P)
- Modified index technique with two photopolymerizations (MI2P)

The sample size was determined by the formula for comparison of means at a confidence level of 95%, with a statistical power of 0.8 and the variance of the pilot test, thus obtaining six samples per group. However, for greater representativeness, it was decided to use fifteen samples per group, generating a total of 90 samples (each with two microhardness records: superficial and at 2 mm). For the preparation of the resin discs, copper washers with 2 mm in height by 5 mm in diameter were used (19) (Figure 1), in which the resin was placed to form the discs with the same dimensions as the copper washers, and then they were photopolymerized according to the experimental group (Figures 2 and 3).

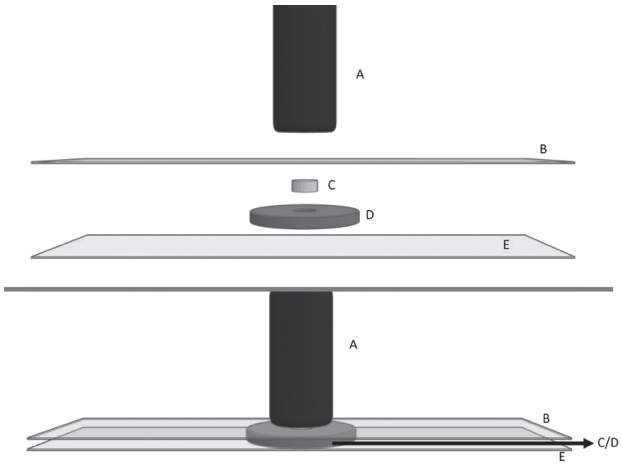

Figure 1. Photopolymerization scheme of D1P and D2P groups. A) light-curing lamp; B) celluloid tape; C) composite resin; D) copper washer; E) glass tile.

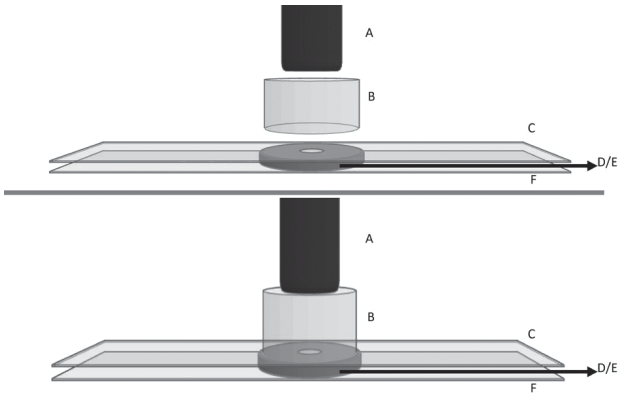

Figure 2. Photopolymerization scheme of CI1P and CI2P groups. A) light-curing lamp; B) 10 mm silicone matrix; C) celluloid tape; D) composite resin; E) copper washer; F) glass tile.

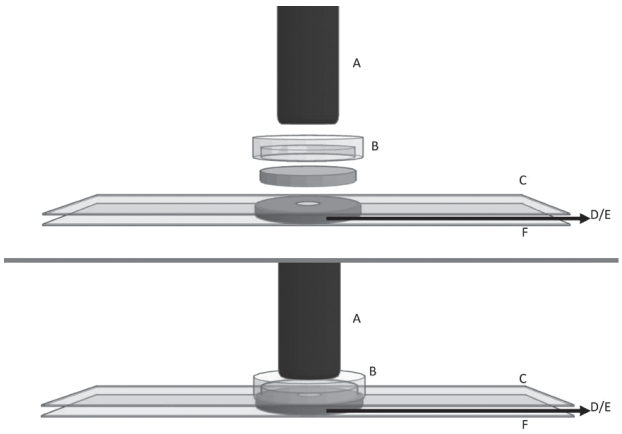

Figure 3. Photopolymerization Scheme of MI1P and IM2F groups. A) light-curing lamp; B) silicone matrix and 4 mm impression tray; C) celluloid tape; D) composite resin; E) copper washer; F) glass tile.

The discs selected for the investigation were those that complied with the aforementioned measures, and those that were scratched, bubbled or poorly photopolymerized were excluded. The resin discs were worked as follows:

D1P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile at the bottom, and a celluloid tape that remained during polymerization was placed on the top and removed before microhardness recording. The resin was individually photopolymerized with an EliparTM DeepCure lamp (3TM, Minnesota, USA) with parameters of 1470 mW/cm^2 per 20 seconds with the composite resin. After 24 hours, all samples from the first photopolymerization group were subjected to the Vickers hardness test (25) with an average of 3 indentations with a load of 200 g per 15 seconds each, taking record of surface microhardness and at 2 mm of the photopolymerized composite resin. Both sides of the light-cured disc were recorded.

D2P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile at the bottom, and a celluloid tape that remained during polymerization and that was removed before microhardness recording, was placed on top. The resin was individually photopolymerized with an EliparTM DeepCure lamp (3MTM, Minnesota, USA) with parameters of 1470 mW/cm^2 per 20 seconds with composite resin. Moreover, in a period no longer than 1 minute, the second photopolymerization was applied, simulating the time it takes us to remove excesses or give touch-ups. The second photopolymerization was applied on the same side where direct light shot was given to the resin disc but, before that, glycerin was applied to remove the oxygen-inhibited layer.

After 24 hours, all samples from the first photopolymerization group were subjected to the Vickers hardness test (25) with an average of three indentations and a load of 200 g for 15 seconds each, taking record of surface microhardness and at 2 mm of

the photopolymerized composite resin. Both sides of the photopolymerized disc were registered.

CI1P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile in the lower part, and a celluloid tape was placed on the upper part, which was removed before photopolymerization, and on this resin a transparent addition silicone matrix (ExaclearTM, GM) with a thickness of 10 mm was placed, and it was made with the help of an empty block of resin 2 mm thick on its walls (Creality, China), which was digitally designed using Thinkercad (Autodesk, Mill Valley, California, USA) and Meshmixer sowtware v. 3.5 (Autodesk, Mill Valley, California, USA) and produced with Shuffle XL 3 printer (Phrozen, Taiwan). After obtaining the matrix, it was given a spray polyurethane bath and with the triple syringe of the dental unit, air was applied at 40 PSI for 20 seconds until the polyurethane did not leave waves due to its still liquid state. Then it was reserved for one hour. After that, resin was individually photopolymerized with an EliparTM DeepCure lamp (3MTM, Minnesota, USA) with the parameters of 1470 mW/cm^2 for 20 seconds with the composite resin. After 24 hours, all samples from the first light-curing group were subjected to the Vickers hardness test (25) with an average of three indentations and a load of 200 g per 15 seconds each, taking record of surface microhardness and at 2 mm of the photopolymerized composite resin. Both sides of the photopolymerized disc were registered.

CI2P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile in the lower part, and a celluloid tape was placed in the upper part, which was removed before photopolymerization, and on this resin a transparent addition silicone matrix (ExaclearTM, GM) with a thickness of 10 mm was placed, and it was made with the help of an empty block of resin 2 mm thick on its walls (Creality, China), which was digitally designed using Thinkercad (Autodesk, Mill Valley, California, USA) and Meshmixer sowtware v. 3.5 (Autodesk, Mill Valley, California, USA) and produced with Shuffle XL 3 printer (Phrozen, Taiwan). After obtaining the matrix, it was given a spray polyurethane bath, and with the triple syringe of the dental unit, air was applied at 40 PSI for 20 seconds until the polyurethane did not leave waves due to its still liquid state, and then it was reserved for one hour. After that, the resin was individually photopolymerized with an EliparTM DeepCure lamp (3MTM, Minnesota, USA) with parameters of 1470 mW/cm^2 for 20 seconds with the composite resin. Moreover, in a period no longer than 1 minute, the second photopolymerization was applied, simulating the time it takes us to remove excesses or give touch-ups. The second photopolymerization was applied on the same side where the direct light shot was given to the resin disc but, before that, glycerin was applied to remove the oxygen-inhibited layer. After 24 hours, all samples from the first light-curing group were subjected to the Vickers hardness test (25) with an average of 3 indentations and a load of 200 g for 15 seconds each, taking record of surface microhardness and at 2 mm of the photopolymerized composite resin. Both sides of the photopolymerized disc were registered.

I2P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile at the bottom, and a celluloid tape was placed on top, which was removed before photopolymerization. On this resin a silicone matrix was placed by transparent addition, with a thickness of 2 mm, which was made with the help of a block, simulating the 2 mm thick resin tray. With a bath of spray polyurethane and with the triple syringe of the dental unit, air was applied at 40 PSI for 20 seconds until the polyurethane did not leave waves due to its still liquid state. And it was reserved for one hour to be used later applying the transparent silicone to prevent it from polymerizing due to the oxygen inhibited layer of the printed resin. The tray was digitally designed using Thinkercad and Meshmixer v. 3.5 software and made with the Shuffle XL 3D printer, giving a total thickness of 4 mm together (2 mm of resin tray and 2 mm of transparent silicone). Under this matrix created together with the printed mold, we proceeded to photopolymerize the resin individually with an EliparTM DeepCure lamp (3MTM, Minnesota, USA)

with parameters of 1470 mW/cm^2 for 20 seconds with composite resin. While the photopolymerization of a disc was applied, the other resin discs were covered with black stretch film, leaving only the disc to be photopolymerized. After 24 hours, all samples from the first photopolymerization group were subjected to the Vickers hardness test (25) with an average of three indentations and a load of 200 g per 15 seconds each, taking record of surface microhardness and at 2 mm of the photopolymerized composite resin. Both sides of the photopolymerized disc were recorded.

MI2P group:

With an mh mini modeling spatula (LM Dark Diamond, Finland), shade A1 composite resin (Reflectys, Itena) (24) was placed inside the copper washers (2 mm in height by 5 mm in diameter) (19). To obtain a smooth surface, the washer was placed on a 10 cm × 10 cm glass tile at the bottom, and a celluloid tape was placed on top, and it was removed before photopolymerization. On this resin a 2 mm thick transparent addition silicone matrix was placed, and it was made with the help of a block, simulating the 2 mm thick printed resin tray. With a bath of spray polyurethane and with the triple syringe of the dental unit, air was applied at 40 PSI for 20 seconds until the polyurethane did not leave waves due to its still liquid state. And it was reserved for one hour to be used later applying transparent silicone to prevent it from polymerizing due to the oxygen inhibited layer of the printed resin. The tray was digitally designed using Thinkercad and Meshmixer v. 3.5 software and made with Shuffle XL 3D printer, giving a total thickness of 4 mm together (2 mm of resin tray and 2 mm of transparent silicone). Under this matrix created together with the printed mold, we photopolymerized the resin individually with an EliparTM DeepCure lamp (3MTM, Minnesota, USA) with parameters of 1470 mW/cm^2 for 20 seconds with the composite resin. While photopolymerization of one disc was applied, the other resin discs were covered with black stretch film, leaving only the disc to be photopolymerized. In addition, in a period of no more than 1 minute, the second photopolymerization was applied, simulating the time it takes us to remove excesses or to give touch-ups. The second photopolymerization was applied on the same side where the direct light shot was given to the resin disc, but before that glycerin was applied to remove the oxygen-inhibited layer. After 24 hours, all samples from the first photopolymerization group were subjected to the Vickers hardness test (25) with an average of three indentations and a load of 200 g per 15 seconds each, taking record of surface microhardness and at 2 mm of the photopolymerized composite resin. Both sides of the photopolymerized disc were recorded.

The data were collected in the instrument prepared for the research study. They were then transferred to Excel to be processed by the SPSS (Statistical Package for the Social Sciences) program, version 26. The Kolmogorov-Smirnov test was used to verify that the data did not have a normal distribution. Subsequently, inferential analysis was performed to determine the association of variables using the Kruskal-Wallis test, and a *post hoc* test was taken for each restoration group. A significance level of 5% was considered.

Due to the level of the research and the fact that no human samples were used, the approval of an ethics committee was not required.

RESULTS

We found that in groups of one photopolymerization, the mean and standard deviation (SD) of surface microhardness in the D1P group was 51.18 (SD = 0.86), while in the MI1P group it was 45.69 (SD = 1.23), and in the CI1P group a mean of 42.87 (SD = 2.78) was found. On the other hand, in the groups of two photopolymerizations, it was observed that in the D2P group the mean surface microhardness was 47.96 (SD = 2.53), in the MI2P group it was 46.90 (SD = 2.03), and in the CI2P group it was 46.97 (SD = 1.41) (Table 1).

Table 1. Description of surface microhardness and at 2 mm of composite resin with conventional and modified index technique with printed tray in one and two photopolymerizations.

Group	Surface Hv X (SD)	Hv at 2 mm X (SD)
D1P	51.18(0.86)	46.30(1.13)
CI1P	42.87(2.78)	32.35(1.23)
MI1P	45.69(1.23)	35.97(1.41)
D2P	47.96(2.53)	40.55(4.90)
CI2P	46.90(2.03)	41.51(1.02)
MI2P	46.97(1.41)	42.38(1.42)

Hv: Vickers microhardness; X: mean; SD: standard deviation.

Regarding microhardness at 2 mm, it was found that when applying a photopolymerization the mean was 46.30 (SD = 1.13) in the D1P group. In

the MI1P group it was 35.97 (SD = 1.41); and in the CI1M group a mean of 32.35 (SD = 1.23) was found. In the two photopolymerization groups it was found that the microhardness at 2 mm had a mean of 40.55 (SD = 4.90) in the D2P group. In the MI2P group it was 41.51 (SD = 1.02); and in the CI2P group a mean of 42.38 (SD = 1.42) was found (Table 1).

Table 2. *Post hoc* test for pairwise comparison for surface microhardness and at 2 mm of composite resin with conventional and modified index technique with printed tray in one and two photopolymerizations.

Study Group		p value	
		Surface microhardness	Deep microhardness
D1P	MI1P	<0.001*	<0.001*
	IC1P	<0.001*	<0.001*
MI1P	D1P	<0.001*	<0.001*
	CI1P	<0.001*	<0.001*
CI1P	D1P	<0.001*	<0.001*
	MI1P	<0.001*	<0.001*
D2P	MI2P	0.339	0.659
	CI2P	0.385	0.229
MI2P	D2P	0.339	0.659
	CI2P	0.996	0.708
CI2P	D2P	0.385	0.229
	MI2P	0.996	0.708

* Significant difference ($p < 0.05$).

It is also observed that there is a significant difference between surface microhardness groups and at 2 mm after one photopolymerization ($p < 0.001$). At the same time, it is found that there are no significant differences between the surface microhardness groups and at 2 mm after the second photopolymerization ($p = 0.519$ and $p = 0.279$) (Table 2).

DISCUSSION

Technological progress has positively contributed to dentistry, since materials and equipment have evolved, so nowadays it is possible to work with digitized dentistry which facilitates treatments for the patient; however, success will also depend on the experience and training of the dentist (1-6). This is how the importance of this research arises, since, with the latest restoration techniques at the time of photopolymerization, the light source is no longer placed directly on the composite resin, but between them is a resin matrix that could be in different sizes.

Gómez Basurto et al. (5) tried to determine the influence of a carbonated beverage on the surface hardness of different commercial resins. They used a study population of 10 samples for each brand of resins, with a total of 60 samples of 15 ± 1 mm in diameter by 1.5 ± 0.5 mm in height. And they found that one of the resins has a mean microhardness of 82.817. In this study, we tried to determine whether there are significant differences between the surface microhardness in three different photopolymerization groups and two light-curing times. For this purpose, fifteen samples were used per group, having a total of 90 samples. Each disc was standardized to measure 5 mm in diameter by 2 mm in height; and the result indicated significant differences in microhardness of the first photopolymerization groups, and no significant differences were found in the second photopolymerization groups. In comparison with the study by Gómez Basurto et al. (5), in this research, a larger number of samples were obtained, and all discs had the same measurements.

Scoville (19) in his research compared the microhardness of a composite resin that had been photopolymerized at different distances, counting with seven groups of ten samples each and cured at distances with and without silicone matrix. Apart from that, the microhardness test used was the Knoop test, and it was used at 4 different points on the surface. The author found that the upper side presented higher microhardness than the lower side; and the highest mean obtained was 44.0 KHN. In addition, he concluded that after applying the first photopolymerization with silicone matrix, it is necessary to apply a second photopolymerization. In this study, a larger sample was used than in the previous study (15 per group instead of 10). Additionally, the microhardness test used was the Vickers test, since it is not possible to use the Knoop test in the country. Similarly, the Vickers test was chosen because it is the most suitable for small and rounded samples; and it was used at 3 different points on each surface. As in the previous study, it was found that there is a higher microhardness on the upper side than on the lower side and, taking the same study as a reference, a second photopolymerization was used in all groups and it was found that there are no significant differences.

Nithya et al. (21) in their study, evaluated the effect of resin polishing on microhardness, using a total of

450 samples and the Struers microhardness test. The authors determined that with polishing there is a higher level of microhardness. In this study, the resin discs that were part of the different study groups were not polished, and the size of the samples was much smaller. It was also found that, at the time of the second photopolymerization, the significant difference that exists in the first photopolymerization disappears. Furthermore, a celluloid matrix was placed to obtain a smooth surface on the resin.

Vásquez-Castro et al. (33) tried to determine the necessary photopolymerization time in a bulk-fill resin at 3 mm thickness, thus measuring the surface microhardness and base microhardness. The authors found that it takes a minimum time of 40 seconds to photopolymerize at the base of the 3 mm thick resin disc. In this research study, unlike the previous one, silicone matrices of different thickness were used to observe the microhardness of the resin at different distances from the light-curing lamp and the resin, using the same time of 40 seconds, and similar results were found.

De León et al. (34) found that intensities lower than 400 mW/cm^2 generate cytotoxicity in the resins and make their mechanical properties decrease. In this research study, a lamp with an intensity of 1470 mW/cm^2 was used, and it was found that an adequate surface microhardness is obtained at 2 mm. Moreover, it was found that applying two photopolymerizations with different techniques studied helps to obtain the same results as a direct restoration.

This study, unlike those found in the literature, was conducted with two different sizes of resin matrices to propose that the matrix can be as low as 2 mm instead of the 10 mm currently indicated in the technique. In addition, it was carried out with the Vickers microhardness test because it is the only one available in the country, and different samples were used in the first and second photopolymerization groups.

The main limitation of the study was the Vickers scale microhardness test, since, nowadays, it is usually used on the Knoop scale; however, in Peru there is only more access to equipment to measure microhardness on the Vickers scale.

CONCLUSIONS

There are no significant differences in surface microhardness and at 2 mm depth of composite resin photopolymerized with the conventional and modified index technique in two photopolymerizations.

There are significant differences in the surface microhardness and at 2 mm depth of the composite resin photopolymerized with conventional and modified index technique in a printed tray in a photopolymerization.

In that sense, the second photopolymerization is important for the reduction of the differences in microhardness that may exist between restoration techniques.

In vivo studies are suggested to reinforce clinical procedures and, if feasible, to modify clinical procedures.

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ORIGINAL ARTICLE

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Dental deafferentation as an etiologic factor of taste dysfunction in male Wistar rats

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ABSTRACT

Objective: To evaluate the influence of dental deafferentation (DD) on the sense of taste in male Wistar rats using the taste reactivity test (TRT). **Materials and methods:** An experimental study was conducted on ten Wistar rats, following ARRIVE 2.0 guidelines. They were randomized and assigned to a control or experimental group, and both groups' cannulae for the TRT were implanted. In the experimental group, exodontia of the three upper molars on the right side was performed. On the third day, TRT was started (day 1) by infusing 1 M of a sweet substance (ingestive) and 3 mM of a bitter substance (aversive) at a rate of 1 mL in 1 minute. This TRT was repeated on days 7, 14 and 21. Ingestive and aversive responses were scored for 1 minute. The data were processed in the SPSS v. 26 statistical package. The Mann-Whitney U test was used to identify differences, and the magnitude of the difference was calculated using Rosenthal's r. **Results:** Ingestive responses to sucrose were obtained on day 1 ($p > 0.05$); different responses were obtained on the other days: day 7 ($p = 0.05$), day 14 ($p = 0.009$), and day 21 ($p = 0.009$). Likewise, aversive responses to denatonium benzoate (DB) were obtained on days 1, 7, and 21 ($p > 0.05$); this was different on day 14 ($p = 0.05$). **Conclusions:** We found a difference in median ingestive responses to sucrose and aversive responses to DB in male Wistar rats due to DD.

Keywords: tooth extraction, taste perception, cannula, Wistar rats.

INTRODUCTION

Sense of taste is essential for life because, apart from preventing the ingestion of toxic substances, it activates the neural pathways for digestion, absorption, and storage of nutrients. A dysfunction of taste perception can have an impact on the quality of life by affecting appetite, body weight, and psychological well-being (1). As a consequence, a change in the perception of this sense can influence a person's health and the risk of chronic diseases such as obesity (2), atherosclerosis, diabetes, liver diseases, hypertension (3), cancer (4), etc.

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There are several factors that can affect taste perception, such as malnutrition, cancer, chronic hepatitis, renal dysfunction, AIDS, encephalocranial trauma, exposure to toxic chemicals, exposure to industrial agents, medication, aging, oral and perioral infections, Bell's palsy, use of dental prostheses, root canal treatments etc. (5). It has been reported that it can also be caused by exodontia of the mandibular wisdom teeth (6, 7), or as a sequel by the administration of dental anesthesia for the surgical procedure (8, 9). However, taste deficits following exodontia of other teeth (upper molars, incisors, etc.) or root canal treatments cannot be explained by damage to the chorda tympani or glossopharyngeal nerve, as the nerve fibers of these nerves do not innervate or go through the anterior surgical site (10-12).

Dental deafferentation (DD) is defined as the elimination or reduction of peripheral afferent neural inputs related to dental and masticatory apparatuses. Examples of DD include tooth loss, local and/or generalized periodontal loosening, inadequate surgical or prosthetic restorations, orthodontic treatments, root canals, defective mastication, etc. (11, 13).

Humans and animals, such as rats and mice, tend to over-consume high-calorie foods. «Reward» has been subdivided into three interdependent psychological processes: hedonia (liking a food), reinforcement (forming associations between stimuli, actions and/or the food) and motivation (wanting the food) (14). *Wanting* is assessed in animals by means of intake tests, such as total mass or volume consumed during a designated period; however, avoiding the consumption of a solution does not necessarily imply that you do not like it, nor does exacerbated consumption imply greater liking for a substance. Consequently, intake measures alone are interpretatively limited. To correct this problem, Grill and Norgren developed the taste reactivity test (TRT), capable of probing *liking* in the absence of *wanting* (15). Taste reactivity (TR) refers to stereotyped orofacial responses provoked by a taste stimulus in animals, including rodents and human beings. To apply this procedure in animals, intraoral cannulae are surgically placed by which taste stimuli can be directly infused and responses can be videotaped for frame-by-frame analysis. TR can be classified as ingestive, aversive, or ambiguous (16, 17).

The objective of this study was to evaluate the influence of DD on the sense of taste in male Wistar rats using TRT.

MATERIALS AND METHODS

Experimental study that followed ARRIVE 2.0 (Animal Research Reporting of *In Vivo* Experiments) guidelines. It was conducted with ten Wistar rats in good systemic health conditions, which were obtained from the animal care laboratory of the Facultad de Medicina of Universidad Peruana Cayetano Heredia (UPCH). Rats were housed in individual 35 × 23 × 18 cm cages, where they received habitual feeding, consisting of grain diet and proportioned *ad libitum* and unlimited access to water. In addition, during the experiments, they were kept in optimal conditions of a 12-hour day-night cycle, with constant temperature (22°C) and humidity (60-70% RH).

Sample size calculation was performed using OpenEpi software based on a previous research study (18) which established that the mean difference in the number of aversive responses to 0.003% quinine in TRT between the control group, and the glossopharyngeal nerve section group was 8.2 (SD 3.4 and 2.1, respectively). Moreover, by using a power of 90% and a significance level of 5%, we were able to calculate that three rats in each group would be sufficient to reject the null hypothesis. This number was increased to five in each group to compensate for the possible loss of cannulae or death during the experimental phase. Rats were randomized and assigned to one of two groups: control and experimental.

To ensure homogenization of the groups, all research subjects were male, aged 8 to 12 weeks and with a statistically non-significant weight when comparing the control group with the experimental group (Table 1).

Table 1. Weight of the research subjects before starting the study.

	Group	n	Mdn	Q1-Q3	Range	U	p
Weight (g)	Control	5	133	129.5-163	44	8	0.35**
	Experimental	5	126	123-165	52		

Mdn: median: Significance level p < 0.05: * significant; ** not significant.

Implantation of intraoral cannulae for TRT in both groups was done under deep sedation, using a combination of ketamine 40 mg/kg and xylazine 5 mg/kg intraperitoneally. Once the rats did not respond to paw pinch, surgery was initiated using a technique similar to that of Parker (19, 20), but using Clay Adams PE-50 cannulae. To prevent loss or

obstruction of the cannula, the same procedure was followed on the opposite side. At the same time, taking advantage of anesthesia, the experimental group underwent extraction of the three upper molars on the right side. Rats were individually housed in cages immediately after surgery. An injection of the analgesic meloxicam 1 mg/kg and penicillin-streptomycin 0.1 mg/kg subcutaneously was administered. To maintain the permeability of the cannulae, distilled water was infused every three days. For infusion of solutions used in the TRT, a 23G × 1" cut needle was connected to the cannula protruding from the nape, which in turn was adapted to a 30 cm DIS extension and a three-way stopcock with a 50 cm extension. Finally, a 3 cc syringe with the solution to be infused was connected to the three-way stopcock.

On the third day of surgery, TRT started (day 1) in a trapezoidal mirrored cabinet, in which rats from both groups were individually placed and the orofacial and body reactions to the intraoral infusion of two flavoring agents were recorded with a video camera at 60 frames per second: 1 M sucrose (ingestive) and 3 mM denatonium benzoate (DB), which is aversive, at a rate of 1 mL in 1 minute. This TRT was repeated on days 7, 14 and 21. The total number of ingestive and aversive responses during the one-minute infusion period and during the following 30 seconds was recorded.

The ingestive responses considered in this research were as follows: 1) mouth movements: rhythmic low-amplitude openings of the mandible, usually during fluid swallowing; 2) tongue protrusion (medial and lateral): rhythmic protrusions of the tongue in the midline, covering the upper incisors, and non-rhythmic extensions of the tongue, which emerges on both sides of the mouth, resulting in an asymmetrical separation of the lips; 3) forepaw licking: rhythmic high-amplitude extensions of the tongue in the midline directed at the forepaws (Figure 1).

The aversive responses were as follows: 1) triangular mouth openings: wide-openings of the jaw revealing the upper and lower incisors with concomitant retraction of the corners of the mouth; 2) head movement: burst of high-frequency side-to-side head movements; 3) forepaw movement: burst of high-frequency movements of one or both forelimbs; 4) fluid ejection: accumulation of fluid outside the mouth, fluid drips into the TRT cabin (21) (Figure 1).

Finally, for the analysis, the reactions recorded during the last 30 seconds of the infusion phase and during the first 30 seconds of the post-infusion phase were scored. The information obtained was inserted in an MS-Excel spreadsheet. It was then processed in the SPSS version 26 statistical package. Since not all variables had a normal distribution, and there are fewer than 50 data in each group, a nonparametric test (Mann-Withney U) was used to identify differences between two independent samples. Finally, the magnitude of the difference was calculated using Rosenthal's r.

All experiments were approved by the Research Ethics Committee of the Facultad de Medicina of Universidad Nacional Mayor de San Marcos (study code no. 0054-2022).

RESULTS

Results are presented with 95% confidence interval. All the time, the significance level was set at $p \leq 0.05$ (Table 2). In the comparison of the number of responses to TRT between the control and experimental groups on day 1, no statistically significant differences were found in the ingestive and aversive responses to sucrose ($p = 0.18$ and 0.43, respectively). Similarly, no statistically significant differences were found in aversive and ingestive responses to DB ($p = 0.47$ and 0.14, respectively). In all cases, a magnitude of difference (Rosenthal's r) < 0.5 was maintained, which is considered a small effect.

When comparing the number of responses to TRT on day 7, no statistically significant differences were found in aversive responses to DB and sucrose ($p = 0.35$ and 0.16, respectively). In contrast, statistically significant differences were found in the ingestive responses to sucrose, where the scores of the control group (Mdn = 197; Range = 120) were higher than those of the experimental group (Mdn = 95; Range = 81), with $U = 3$, $p = 0.05$, and a magnitude of difference of 0.623, which in Cohen's scale is considered as an intermediate effect. No ingestive responses to DB were obtained.

When evaluating the number of responses to TRT on day 14, statistically significant differences were found in the ingestive responses to sucrose, where the scores of the control group (Mdn = 205; Range = 81) were higher than those of the experimental group (Mdn = 98; Range = 100), with $U = 0$, $p = 0.009$, and a magnitude of difference of 0.83, which on Cohen's scale is considered as a great effect. In the same sense, statistically significant differences were found in the aversive responses to DB, where the scores of the control group (Mdn = 142; Range = 124) were higher than

those of the experimental group (Mdn = 34; Range = 79), with U = 3, p = 0.05, and a magnitude of the difference of 0.63, which on Cohen's scale is considered as an intermediate effect. At the same time, statistically significant differences were found in the aversive responses to sucrose, where the scores of the experimental group (Mdn = 7; Range = 23) were higher than those of the control group (Mdn = 3; Range = 5), with U = 3, p = 0.04, and a magnitude of the difference of 0.65, which on Cohen's scale is considered as an intermediate effect.

Finally, in the comparison of the number of responses to TRT on day 21, no statistically significant differences were found in aversive responses to DB (p = 0.08) or in aversive responses to sucrose (p = 1). Likewise, no ingestive responses to DB were obtained, as it occurred on days 7 and 14. In contrast, statistically significant differences were found in ingestive responses to sucrose, where the scores of the control group (Mdn = 207; Range = 159) were higher than those of the experimental group (Mdn = 85; Range = 68), with U = 0, p = 0.009, and a magnitude of difference of 0.83, which on Cohen's scale is considered as a large effect.

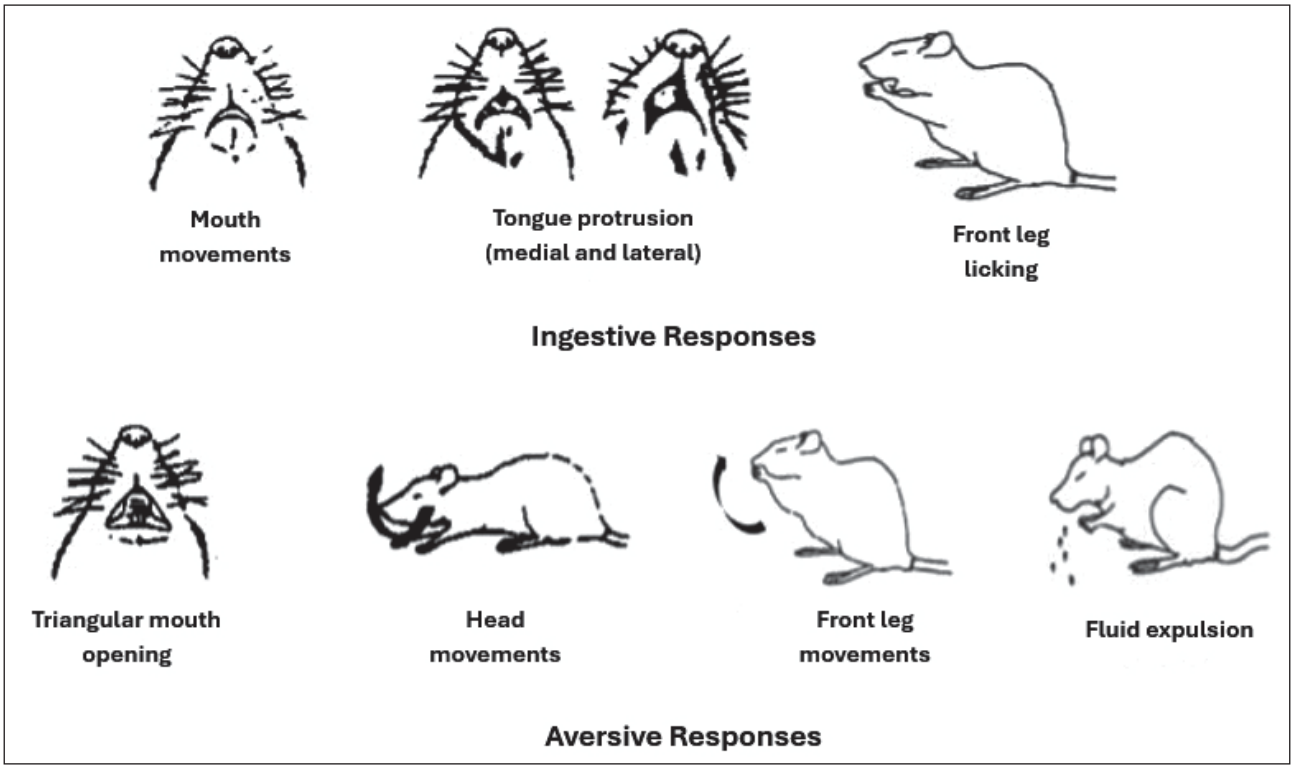

Figure 1. Behavior during the taste reactivity test. Adapted from Grill et al. (18).

Table 2. Comparison of the number of TRT responses.

	Responses	Group	n	Median	Q1-Q3	Range	U	p	Rosenthal's r
Day 1	Ingestive (sucrose)	Control	5	184	98-226	150	6	0.180**	0.42
		Experimental	5	235	145.5-266.5	153			
	Aversive (DB)	Control	5	61	36-179.5	183	9	0.140**	0.23
		Experimental	5	135	84.5-178	136			
	Ingestive (DB)	Control	5	0	0-0	0	7.5	0.470**	0.47
		Experimental	5	0	0-2.5	3			
	Aversive (sucrose)	Control	5	2	0-9	12	9	0.430**	0.25
		Experimental	5	0	0-3	3			
Day 7	Ingestive (sucrose)	Control	5	197	121.5-211.5	120	3	0.050*	0.62
		Experimental	5	95	73-141.5	81			
	Aversive (DB)	Control	5	142	94-251.5	217	8	0.350**	0.30
		Experimental	5	186	172.5-269	107			
	Ingestive (DB)	Control	5	0	0-0	0			
		Experimental	5	0	0-0	0			
	Aversive (sucrose)	Control	5	6	3-12	12	6	0.160**	0.44
		Experimental	5	12	7.5-20	17			
Day 14	Ingestive (sucrose)	Control	5	205	168-221	81	0	0.009*	0.83
		Experimental	5	98	43.5-128.5	100			
	Aversive (DB)	Control	5	142	57.5-158	124	3	0.050*	0.63
		Experimental	5	34	26.5-84	79			
	Ingestive (DB)	Control	5	0	0-0	0			
		Experimental	5	0	0-0	0			
	Aversive (sucrose)	Control	5	3	2-4.5	5	3	0.040*	0.65
		Experimental	5	7	4.5-23.5	23			
Day 21	Ingestive (sucrose)	Control	5	207	139-252	159	0	0.009*	0.83
		Experimental	5	85	70-109	68			
	Aversive (DB)	Control	5	179	103.5-249	204	4	0.08**	0.56
		Experimental	5	90	45-120.5	113			
	Ingestive (DB)	Control	5	0	0-0	0			
		Experimental	5	0	0-0	0			
	Aversive (sucrose)	Control	5	7	4.7-8.5	7	12.5	1.000**	0
		Experimental	5	6	4-12.5	13			

Significance level $p < 0.05$: * significant; ** not significant.

DISCUSSION

Multiple DD studies have been conducted in rodents to reduce their chewing ability by molar extraction (22, 23), root canal treatment (24), soft diet feeding (25, 26), or bite plate placement (27, 28). In this research study, DD was provoked in the study subjects by exodontia of the three upper molars on the right side.

A little-known aspect is that DD affects the sense of taste because trigeminal and gustatory somatosensory inputs converge in the cortex, thalamus, parabrachial nucleus, etc., and anatomical studies have revealed projections from the V pair to the face-lateral region of the nucleus of the solitary tract (NST), the first gustatory relay at the central level, which receives projections from the chorda tympani (CT) nerve of

the facial (29, 30) or glossopharyngeal (GL). In one study, it was determined that responses to flavorings applied to the rat tongue were electrophysiologically registered in NST units while manipulating the lingual and mandibular nerves. The section of either of these nerves resulted in a significant decrease in the taste response; however, it was even greater when the tooth nerve was cut. Therefore, the parameters of the texture properties of food monitored by the teeth that function as force sensors clearly contribute to «taste» signaling (31).

The relationship between DD and cognitive problems such as Alzheimer's dementia, spatial memory impairment, Parkinson's disease, heart disease, osteoporosis, depression and anxiety has been studied (11). However, there are a few studies that analyze the relationship between DD and taste dysfunction without direct injury to the chorda tympani or glossopharyngeal nerve. The study by Boucher et al. (10) is interesting because it correlates taste dysfunctions and DD in humans by electrogustometry (EGM). In this study it was determined that the greater the number of missing teeth, the higher the EGM threshold, regardless of the age of the subject. As it is known, the higher the threshold, the lower the taste sensation. However, taste deficits following other types of DD, such as exodontia of other teeth (upper molars, incisors, etc.) or root canal treatments, cannot be explained by damage to the CT or GL nerve, because the nerve fibers of these nerves do not innervate or go through the anterior surgical site (10, 12).

TRT is mostly used in conditioned taste aversion paradigms (32). However, it is also used in a wide range of experimental situations, including research on taste palatability, satiety, sodium depletion (16), and in studies related to learning and memory using consummatory behavior and classical conditioning (33). In the pioneering research study of Grill and Norgren (34, 35), behaviors that make up the hedonic (ingestive) and aversive pattern in adult rats were thoroughly described. Initially, four orofacial components and five body response components were identified. The hedonic (ingestive) pattern includes rhythmic mouth movements (MM), medial tongue protrusions (MTP) and lateral tongue protrusions (LTP). In contrast, the aversive pattern incorporates triangular mouth openings (TMO), chin rubbing against the floor, rapid head movements (HM), forward foreleg movements (FFM) and washing with both forelegs over the muzzle (WFL). Some later studies have narrowed the pattern of aversive responses to TMO, FFM and FB, and have added front paw licking (FPL) to the hedonic pattern (18). In our research study, MM, tongue protrusion (including MTP and LTP) and WFL were considered as ingestive patterns. The aversive pattern included TMO, HM, FFM and fluid expulsion.

Since the number of aversive responses to sucrose and ingestive responses to DB in the TRT were negligible, only ingestive responses to sucrose and aversive responses to DB were considered in the final analysis. In this study, it was observed that the number of ingestive reactions to sucrose decreased significantly from the first week in the experimental group with respect to the control group, statistically significantly in all cases. In contrast, aversive reactions to DB were variable, increasing in the experimental group in the first week and decreasing in the second and third week when compared to the control group, with statistically significant differences being found on the second week. On the first day of TRT, no statistically significant differences in ingestive responses to sucrose or aversive responses to DB were found because it is presumed that little time passed by to have changes in the sense of taste for DD.

These results cannot be compared with other research studies because, in the literature review, no studies measuring these variables were found, and aversive responses were not measured with DB. However, there are reports of TRT in murines subjected to section of the CT nerve from the VII pair (carries taste information from the anterior 2/3 of the tongue) or GL (carries taste information from the posterior 1/3 of the tongue), which could be considered another form of deafferentation. For example, in the study by Grill and Schwartz (36), when comparing ingestive responses by sucrose infusion at different concentrations in rats with CT and GL nerve section versus the control group, they observed that the ingestive score increased significantly with increasing sucrose concentration in the control group ($F2.6 = 6.3$; $p < 0.05$); in contrast, CT + GL rats showed significantly fewer total ingestive responses than intact rats at each sucrose concentration tested ($F2,6 = 6.7, 5.6, 7.8$; $p < 0.05$). All taste aversion studies that employed TRT were conducted with quinine hydrochloride; however, DB is three thousand times more bitter than quinine.

In the study by King et al. (37), in which rats were exposed to one of three surgical conditions (section of the LG bilaterally, removal of 8-10 mm of the LG bilaterally, and control group in which only LGs

were exposed), TRT was used by infusion of quinine (3 mM) or distilled water at 17, 52, or 94 days after surgery. Scored aversive behaviors included TMO, chin rubbing, HM and FFM. A two-factor analysis of variance indicated significant main effects of stimulus ($F_{(1,65)}$ = 92.55; p < 0.001) and nervous condition ($F_{(6,65)}$ = 7.26; p < 0.001), as well as a significant interaction ($F_{(6,65)}$ = 7.713; p < 0.001). When water was the stimulus, very few aversive behaviors occurred, regardless of the GL condition. In contrast, quinine infusion provoked many aversive behaviors, but only in animals with intact nerves. Among the limitations of the study, we have the lack of homogenization of the sample, a situation that we tried to remedy with the initial weight of the research subjects.

CONCLUSIONS

In this investigation, a difference was found in the medians of ingestive responses to sucrose and aversive responses to DB in male Wistar rats as a consequence of DD, being lower in the experimental group on day 7 (ingestive to sucrose), day 14 (ingestive to sucrose and aversive to DB) and day 21 (ingestive to sucrose), and higher in the experimental group on day 14 (aversive to sucrose). It is suggested to extend this line of research through the evaluation of taste function by means of a histomorphometric study of the goblet papilla in albino rats.

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ORIGINAL ARTICLE

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Teaching performance perceived by a population of students associated with the level of satisfaction self-reported by the professors of the Degree of Dental Surgeon of the Facultad de Estudios Superiores Zaragoza of the Universidad Nacional Autónoma de México

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ABSTRACT

Objective: To describe the association between the teaching performance perceived by a population of students and the level of satisfaction self-reported by the professors of the bachelor's degree program in Dental Surgery of the Facultad de Estudios Superiores Zaragoza of the Universidad Nacional Autónoma de México. **Materials and methods:** Observational, prolective, cross-sectional, descriptive study, conducted in two phases. The first phase showed the self-reported job satisfaction of 123 academics; in the second phase, 120 students were surveyed to evaluate their 6 very satisfied teachers and 140 for the 7 dissatisfied ones, for which a survey adapted from the Department of Teaching Evaluation of the faculty was applied. **Results:** When associating the performance of the 6 teachers most satisfied with their job with the perception that their 120 students have of them, the results show that 2% (n = 2) consider that the academics have a poor performance vs. 44% (n = 53) who consider that they have an excellent performance. As for the 7 teachers identified as very dissatisfied, from the students' point of view, 10% (n = 14) consider the performance poor; and for 49% (n = 68), it is excellent. The job satisfaction self-reported by the 13 academics and the teaching performance

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perceived by their students did not show statistically significant differences. For the students, a teacher has excellent performance despite job dissatisfaction and poor performance even when he or she perceives himself or herself as very satisfied. **Conclusions:** The research results show no association between teaching performance and job satisfaction according to students. A teacher's attitude towards students does not always coincide with his or her level of job satisfaction.

Keywords: assessment, job satisfaction, professional competence, students.

INTRODUCTION

Teaching performance has been evaluated in Mexico since 1990; and it is considered a strategic instrument for the improvement of the educational system from which some of the educational changes are made in accordance with current policies. Within the dimensions that evaluate the teaching performance is the satisfaction with the work done, which has an impact on students. Teacher performance is a topic that is discussed in all educational institutions. Professors, during their work, transmit knowledge through didactic strategies. Likewise, job satisfaction and dissatisfaction are reflected in the attitude that the professor has towards the student in the classroom.

The term "teaching performance" has been conceptualized and studied by several authors and refers to the set of actions that professors perform both inside and outside the classroom. It also aims to promote student learning. Such activities should be aligned with the objectives and competencies defined in a curriculum based on the principles of the institutional educational model (1). However, Quintero and Orozco (2) point out that teaching performance is the ability to express the capacity and characteristics of a teacher to improve the learning process in relation to the capacity and effort made by the student.

To know whether teaching performance is adequate, results should be evaluated to plan and implement educational policies with the purpose of improving not only the quality of the educational system, but also salary compensation programs for professors, thus obtaining additional economic resources for higher education institutions (3), among others. Esquerre and Pérez (4) point out that the evaluation of teaching performance is a systemic process by which valid and reliable data are obtained, and which facilitates the assessment of the effect produced on the student.

In general terms, teaching performance refers to the capacity for teaching, participating in the learning process in a creative manner, constant updating, mastery of knowledge and teaching methods, as well as an attitude and behavior congruent with the ethical and academic principles of the institution (5) while the evaluation of teaching performance is understood as a process that issues value judgments on the quality of compliance with teaching responsibilities in teaching-learning and that influences students' development (6).

From an economic-administrative perspective, it is the consumer who evaluates the quality of the product offered by the supplier. In the educational environment, students act as evaluators, since they are the recipients of the "product" given by the professor. Therefore, the information provided is considered reliable and allows us to evaluate the educational effect on students (2, 7). By linking job satisfaction with academic performance in the classroom, in a real environment, it is possible to understand how teacher job dissatisfaction caused by factors such as class schedule, number of hours worked, teamwork dynamics, personal relationships with colleagues, personal references, among others, can affect the transmission of knowledge to students.

In the case of Universidad Nacional Autónoma de México (UNAM), the General Directorate of Educational Evaluation oversees teaching performance. However, when the process is coordinated, the evaluations are designed and implemented by the schools or faculties according to the specific characteristics of their populations, so there are no general guidelines covering the totality of the institution's professional training programs (8). Therefore, assessing the teaching performance from students' perspective allows us to have another look at the teacher's attitude in the classroom. This can help to develop strategies that foster teachers' self-realization in their work and, in turn, promote commitment, responsibility, psychological health, fullness of thought, etc., which improves the quality of education and contributes to the development of an educational project of excellence that benefits students.

Students can perceive whether the teacher is engaged in his or her work or is simply fulfilling his or her working hours. Therefore, it is important for the professor to consider aspects that may influence students' perception of their work, such as class management, methodology and evaluation. Thus, classroom management refers to the skills and techniques used by professors to keep students organized, attentive, and academically

productive in class. In essence, this includes everything professors can do to facilitate or enhance student learning, including factors such as behavior, setting, materials, and activities (9, 10). The purpose is to create a healthy and disciplined educational environment that fosters a good teaching-learning process with responsibility and hard work (11).

The teaching method is defined as the assignment, explanation, instruction and demonstration through activities to achieve student learning, i.e., the teaching objective (12). Finally, evaluation refers to the grade or the way in which the professor perceives the degree of competence or incompetence of the knowledge demonstrated by a student in an exam or an exercise, without leaving aside the perception of the student's qualities or circumstances to get a grade (13).

In this context, the purpose of this study was to compare the teaching performance perceived by a population of students and the level of satisfaction self-reported by the professors of the Degree in Dental Surgeon of the Facultad de Estudios Superiores Zaragoza (FES Zaragoza) of UNAM.

MATERIALS AND METHODS

An observational, prolective, cross-sectional, and descriptive study was conducted in two phases. In the first one, the self-reported job satisfaction of 123 academics of the Degree of Dental Surgeon of the FES Zaragoza (14) was determined by applying the questionnaire "Multidimensional scale of teaching job satisfaction", adapted from Barraza (15). Then, based on the 25th and 75th percentile of the total number of academics, six professors with the lowest scores (≤ 69) and seven with the highest scores (≥ 87) were selected to be assessed by their students.

In the second phase, based on a selection sampling, a total of 120 students were surveyed to evaluate six very satisfied professors and 140 for seven very dissatisfied professors, for which they applied an instrument adapted from the survey of the Department of Teacher Evaluation of the FES Zaragoza, which evaluates the performance of professors in the classroom (16). The questionnaire with twenty questions with Likert-scale responses comprises three dimensions: classroom management, teaching method, and learning assessment. The reliability of the questionnaire had a Cronbach's α of 0.98.

The questionnaire for students to evaluate their professors was self-administered anonymously within the faculty facilities. The questionnaires were collected the same day they were administered. The data were processed in the SPSS statistical package. v. 20, by which the descriptive statistics of the study variables were obtained. The statistical significance test for nominal qualitative variables was the chi-square test and for ordinal qualitative variables it was the Mann Whitney U test with a confidence level of 95% ($p < 0.05$).

Finally, the study was approved by the Ethics and Bioethics Committee of FES Zaragoza to avoid conflicts of interest by the authors.

RESULTS

The results of job satisfaction of the 123 academics surveyed showed that 25% (n = 31) are very dissatisfied, 48% (n = 59) report being satisfied and 27% (n = 33) mention being very satisfied (Table 1). From this total of professors, thirteen of them who obtained the highest and lowest scores in job satisfaction were taken to be subsequently assessed by their students.

Table 1. Self-perceived level of satisfaction by the professors of the Degree of Dental Surgeon of FES Zaragoza.

Variable	100%	n = 123	Very satisfied		Satisfied		Very dissatisfied	
			%	n	%	n	%	n
Perception of the salary earned								
Unfair*	54	66	8	10	25	31	20	25
Fair	46	57	19	23	23	28	5	6
Salary covers basic needs and entertainment								
Never	28	34	3	4	10	12	28	18
Sometimes	26	32	5	6	15	19	6	7
Always	46	57	19	23	23	28	5	6

Variable	100%	n = 123	Very satisfied		Satisfied		Very dissatisfied	
			%	n	%	n	%	n
Adequate facilities								
Never	18	22	2	2	2	2	15	18
Sometimes	36	44	6	8	23	28	6	8
Always	46	57	19	23	23	29	4	5
Training by the institution								
Never	16	20	1	1	4	5	11	14
Sometimes	32	39	2	3	19	23	11	13
Always	52	64	24	29	25	31	3	4
Permission for external courses								
Never	21	26	0	0	9	11	12	15
Sometimes	33	41	6	7	18	22	10	12
Always	46	56	21	26	21	26	3	4
There is job recognition								
Never	31	38	2	2	9	11	20	25
Sometimes	30	37	4	5	22	27	4	5
Always	39	48	21	26	17	21	1	1
Labor autonomy								
Never	3	4	0	0	0	0	3	4
Sometimes	12	15	1	1	5	6	7	8
Always	85	104	26	32	43	53	15	19
Promotion Opportunity								
Never	28	35	0	0	14	17	15	19
Sometimes	30	38	2	2	22	27	8	10
Always	42	50	25	31	12	15	2	2
Relationships between colleagues								
Never	10	13	0	0	3	4	7	9
Sometimes	18	22	3	4	7	9	7	9
Always	72	88	24	29	38	46	11	13
Teamwork is encouraged								
Never	24	29	1	1	5	6	17	22
Sometimes	37	46	6	7	27	33	5	6
Always	39	48	20	25	16	20	3	3
Availability of time for living together								
Never	7	9	0	0	2	2	6	7
Sometimes	20	24	2	3	10	13	6	8
Always	73	90	25	30	36	44	13	16
Opportunity for personal development								
Never	19	24	0	0	8	10	11	14
Sometimes	36	44	4	5	20	25	11	14
Always	45	55	23	28	20	24	3	3
Total	100%	123	27	33	48	59	25	31

In classroom management dimension, students were asked about the professor's clarity of the concepts of the subject, relation of the subject with practical experiences of the profession, resolution of doubts, pace of the class, use of oral language and behavior. It was found that 28% (n = 73) of the students consider that professors have a poor management of their class; 45% (n = 118) think that professors deliver a fair performance, while 27% (n = 69) believe that they do it in an excellent way.

In terms of the teaching method, 27% (n = 70) of students report that professors have a poor management since the structure, the coherence of activities, and the materials used do not allow to achieve the learning objectives, so the interest in the class is lost. On the other hand, 43% (n = 114) consider that professors deliver a fair performance; and 30% (n = 76) believe that they do it in an excellent way.

26% (n = 67) of students think that the learning assessment dimension carried out by professors is poor; 34% (n = 89) consider that they do it fairly; however, 40% (n = 104) believe that professors are excellent when assessing.

When associating the performance of six very job-satisfied professors with the perception that their 120 students have of them, results show that 2% (n = 2) believe that the academics have a bad performance versus 44% (n = 53) who consider that their performance is excellent. As for those seven professors identified as very dissatisfied, from the point of view of their 140 students, 10% (n = 14) consider teaching performance to be poor, and for 49% (n = 68) it is excellent (Figure 1).

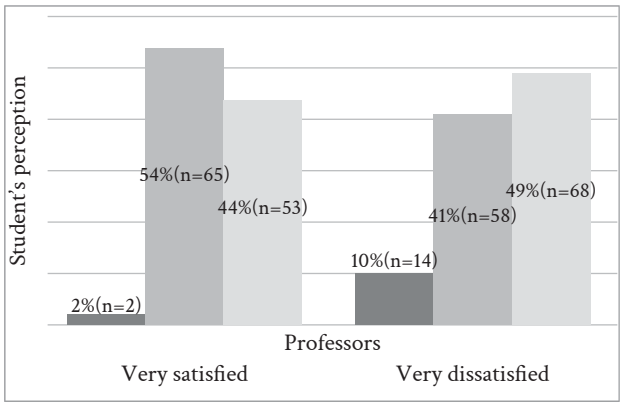

Figure 1. Assessment of teaching activity by a population of students and level of satisfaction self-reported by professors.

The job satisfaction self-reported by the thirteen professors with the highest and lowest job satisfaction scores, in relation to the teaching performance perceived by their students, did not show a statistically significant difference.

Therefore, for students, professors have an excellent performance despite their job dissatisfaction, and they may have a bad performance even when professors perceive themselves as very satisfied.

DISCUSSION

Internationally, it is recognized that educational quality is a serious problem in developing countries. In the case of Mexico, the Ministry of Public Education (SEP), in charge of educational policy, and the National Institute for the Evaluation of Education consider that educational quality is a consequence of teaching performance, on the grounds that, when students get higher scores on standardized tests —which are applied on a large scale nationwide—, educational level improves and the main elements for achieving this are professors (17-19).

The Ministry of Education (SEP), in its guidelines, states that teacher performance evaluation means to evaluate, on the one hand, the degree of fulfillment of their functions and responsibilities established by the institution and, on the other hand, the quality with which the function is carried out in terms of performance and goals achieved in a given time (20), so research studies conducted to assess teaching performance revolves around these purposes. An example of this is the study conducted by Zavala et al. (21) who evaluated teaching attitude along with the didactic and evaluation strategies that have an impact on the professional development of students under the criteria of the educational model of their institution, without considering other indicators that would allow them to know the teacher's satisfaction with the work done.

Among the studies that go beyond the concept of quality in terms of performance and achievements obtained in a certain period of time is that of Martínez-Chairez et al. (22), whose purpose was to show that educational quality not only depends on the performance of the professor, but that there are other factors that need to be considered. That study showed that there is no relationship between teachers' years of service and their students' scores on standardized tests, and there is no relationship between teacher performance and the context in which they work, and, above all,

between teacher performance and educational quality, an aspect that coincides with our study.

García and Medécigo (23), in an exploratory study to determine the criteria used by students to evaluate teaching effectiveness and ineffectiveness showed that, to determine this, they use the 'process' criterion, which includes teaching and mastery of the subject which the teacher displays when teaching. They also observed that teacher's punctuality and attendance are more relevant in determining teaching effectiveness than the way in which learning is assessed. The second place is occupied by the "presage", specifically the teacher's personality traits; and, finally, the "product", that is, the set of perceived learning results which were scarcely mentioned as a criterion for determining teaching effectiveness. In this sense, the authors of this research study highlight the need to include items that globally evaluate the course and the teacher, a statement that coincides with the results of our study.

Educational quality cannot be solved by only giving importance to the evaluation of the category "teacher performance" —which is generally quantitative—, but emphasis should be put on the qualitative aspects related to the subject, as pointed out by Díaz-Barriga (24): "teaching evaluation will remain trapped in the instruments that are currently known, which [...] leave the "teaching function" as a black box [...]. Finally, in the teaching evaluation, it will be necessary to clarify the purposes for which this task is performed: it is evaluated to judge, make decisions, sanction, or it is evaluated to improve the performance of the teaching work" (p. 74).

CONCLUSIONS

The results of this research study indicate that, from students' perspective, there is no association between teaching performance and job satisfaction. This is because it has been observed that there are teachers with poor performance who are very satisfied with their work and others with good performance who feel very dissatisfied. Therefore, a teacher's job satisfaction or dissatisfaction is not necessarily reflected in his or her attitude toward students in the classroom.

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ORIGINAL ARTICLE

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Remineralizing potential of synthetic saliva: an *in vitro* study

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ABSTRACT

Objective: To evaluate the remineralizing effect of synthetic saliva on eroded bovine dental enamel. **Materials and methods:** 50 enamel blocks were prepared from bovine teeth. The specimens were divided into 5 study groups according to treatment: group A (Colgate Total®, toothpaste containing fluoride), group B (MI Paste Plus®, toothpaste containing casein phosphopeptide, amorphous calcium phosphate [CPP-ACP] with fluoride), group C (Salival® Solution, synthetic saliva), group D (distilled water) and group E (no treatment). All specimens in groups A, B, C and D received 0.5% citric acid attacks for 2 minutes at 0, 8, 24 and 32 hours. After each acid attack, toothpastes corresponding to each treatment group were applied. The degree of mineralization was then evaluated by Raman microscopy and surface microhardness by Vickers microhardness. **Results:** Regarding the degree of mineralization and surface hardness, no significant differences ($p > 0.05$) were found in the eroded bovine tooth enamel treated with Colgate Total®, Mi Paste Plus® and Salival® Solution in comparison with the healthy enamel samples. But all presented a significantly higher degree of mineralization and surface hardness than the eroded bovine tooth enamel samples preserved in distilled water ($p < 0.05$). **Conclusion:** This *in vitro* study shows that the synthetic saliva Salival® Solution has a remineralizing potential on eroded bovine enamel.

Keywords: artificial saliva, dental erosion, dental remineralization.

INTRODUCTION

Demineralization and remineralization of tooth enamel are cyclic and dynamic processes that occur in the mouth (1-3). Demineralization is the process by which minerals, such as calcium and phosphate, are dissolved from the enamel surface due to the action of acids, thus weakening the tooth structure. On the other hand, remineralization is the process of replacing the minerals lost during demineralization. In this process, the action of saliva plays a fundamental role, since it takes the lost calcium and phosphates back to the dental tissue (4, 5).

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These processes are especially important in two highly prevalent oral diseases, which are caries and dental erosion. Dental erosion is a process in which dental tissues are worn away due to the action of acids, either of extrinsic or intrinsic origin. Extrinsic origin comes from dietary acids, excessive consumption of carbonated or acidic beverages or certain habits. Intrinsic origin comes from the acid reflux of the stomach and frequent vomiting. Dental caries is mainly caused by bacteria that produce acids from sugars and starches in the mouth (6, 7). Saliva plays an important role in the remineralization of tooth enamel as it helps regulate the pH of the mouth and stimulates salivary flow. An alkaline pH and increased salivary flow favor remineralization by shifting the chemical equilibrium toward mineral precipitation, and by providing the necessary minerals for hydroxyapatite crystal formation (8).

There are patients who may have problems with dry mouth, mainly due to a decrease in salivary secretion, which is frequent in the elderly and in patients under pharmacological treatment. These patients present an increased risk of developing caries, periodontal disease, candidiasis, among others. In this context, the use of artificial saliva is indicated as a palliative measure until the etiological causes of xerostomia are resolved (9, 10).

Artificial saliva can have remineralizing properties due to its mineral content, such as calcium and phosphate, which are essential in the remineralization process of dental enamel, thus promoting the formation of hydroxyapatite crystals and improving the resistance of enamel to acid decomposition caused by bacteria in dental plaque or acid attack of various agents (7, 11).

Saliva substitutes have been shown to be useful for the relief of dry mouth. They are made with a neutral pH and contain electrolytes in a concentration that is similar to normal saliva. Their matrix corresponds to mucin or methylcellulose. Mucin-based products are better tolerated and last longer. They are available as *sprays*, rinses and gel (12).

An artificial saliva present in the Peruvian market is Salival® Solution, which is a preparation of synthetic saliva similar to the mixture of the secretion from the three pairs of salivary glands (parotid, submaxillary and sublingual). It is characterized by being a colorless, somewhat opalescent and viscous liquid. Its composition is very similar to natural saliva, especially in its inorganic ions Ca^{++}, Mg^{++}, K^{++} and $C1^{-}$ and in the percentage ratio of these ions with respect to the high purified aqueous volume. It also has a viscosity and pH equivalent to natural saliva. The objective of this *in vitro* study was to evaluate the remineralizing effect of a synthetic saliva on eroded bovine dental enamel.

MATERIALS AND METHODS

Type of study

It is an experimental *in vitro* study.

Samples

Heads of cattle were purchased for commercial reasons, i.e., for consumption. Permanent mandibular incisors were then extracted. Selected teeth were free of cracks, fractures, hypoplasia, and white spot lesions. They were subsequently stored in 0.1% thymol solution (pH 7.0). Based on previous studies, it was decided to use 10 bovine enamel samples per study group (13, 14). 50 bovine tooth enamel blocks (4 mm × 4 mm × 1 mm) were prepared from the vestibular surface of the bovine crown. Specimens were cut using a low-speed diamond blade. Surfaces were polished using granulation water sandpaper 600, 800, 1000, 1200, 1500, 1800 and 2000 to obtain a homogeneous surface on all samples. Finally, these were encased in acrylic resin to facilitate handling, and were kept at 100% humidity with distilled water until the start of the experiment.

Study Groups

Samples were randomly divided into five study groups according to treatment:

1. Group A: Colgate Total® (toothpaste containing fluoride)
2. Group B: MI Paste Plus® (toothpaste containing casein phosphopeptide-amorphous calcium phosphate [CPP-ACP] with fluoride)
3. Group C: Salival® Solution (synthetic saliva)
4. Group D: Control distilled water
5. Group E: Control enamel samples without treatment or acid cycle

Procedures

All specimens in groups A, B, C and D received acid attacks by immersing the bovine enamel of all samples (ten per group) in a container with 6 mL of 0.5% citric acid for 2 min at room temperature at 0, 8, 24 and 32 hours. It was washed with distilled water after each acid attack. Group E samples did not receive acid attack.

After each acid attack, toothpastes corresponding to each treatment group were applied for 3 minutes with

an electric toothbrush and then rinsed with distilled water.

During the whole process, the samples of groups A, B and C were preserved in artificial saliva, which was changed every day. On the other hand, the samples corresponding to group D were preserved in distilled water until the next acid attack. Group E samples were preserved in distilled water. The degree of mineralization was then evaluated by Raman microscopy and the surface microhardness by Vickers microhardness.

Degree of mineralization

The degree of mineralization was evaluated with Raman microscopy, using a confocal Raman microscope alpha 350RA (WITec GmbH, Ulm, Germany) of the Laboratory of Mycology and Biotechnology "Marcel Gutiérrez-Correa" from Universidad Nacional Agraria La Molina, equipped with a laser of 785 nm wavelength (50 mW power) and a UHTS spectrometer (300 lines/mm) with a CCD camera as detector.

At each sample, twenty equidistant points along an eighty-five µm line were measured, and at each point 20 Raman spectra of 0.1 s each were taken and calculated. The location of the study area on each specimen was determined using a Zeiss EC 50x objective and Köhler white light LED illumination provided by the Raman microscope.

Characteristic spectra of tooth enamel were obtained based on the concentration of molecular compounds. The value given to the peak area corresponding to the vibrational mode of the phosphate ion v1 was counted to calculate the degree of mineralization by normalizing all values with respect to that found in group E.

Surface microhardness

Surface hardness was evaluated using an LG Vickers microhardness tester (HV 1000). Microhardness was measured after the acid cycling with 50 g pressure for 5 seconds. 5 microhardness measurements were recorded for each specimen and values in kg/mm2 were obtained. In addition, the hardness loss percentage (HLP) with respect to group E was analyzed.

Statistical analysis

For the statistical analysis of microhardness and relative mineral amount data obtained by Vickers hardness and Raman microscopy assays, respectively, STATA 16 software (StataCorp LLC, Texas, USA) was used. For descriptive statistics, mean values and standard deviations were considered for each study group, as well as box plots for a better data observation. For inferential statistics, Bartlett test was first used to assess homoscedasticity. Once the homogeneity of variances was verified, a one-factor ANOVA test was performed to find differences between groups with a significance of 5% (p = 0.05). The Bonferroni post-test was then used to compare the mean between groups.

RESULTS

Figure 1 shows the box plot regarding the degree of mineralization by Raman microscopy, in which it can be observed that the remineralizing activity in bovine enamel, produced by Salival® Solution artificial saliva, is similar to Colgate Total® and MI Paste Plus® pastes.

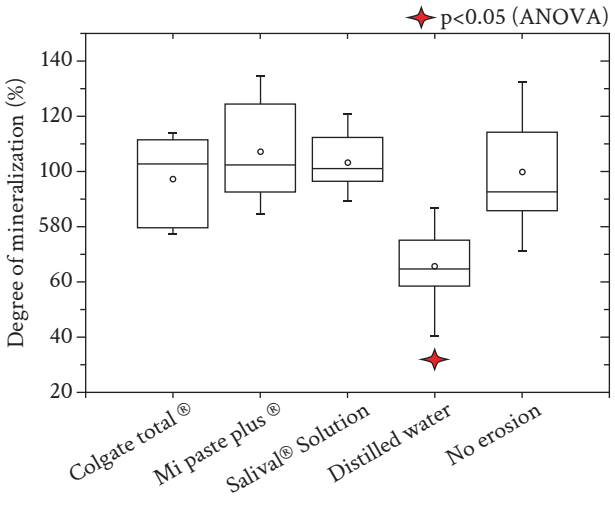

Figure 1. Box plot from the degree of mineralization in the groups studied. The star indicates the group with significant differences with respect to the others at the 0.05 level.

Table 1. Descriptive statistics of the results obtained for the degree of mineralization in the groups studied.

	Degree of mineralization (%)		
	Mean	**SD**	*
Group A: Colgate Total®	97.51	15.10	a
Group B: MI Paste Plus®	107.49	17.27	a
Group C: Salival® Solution	103.10	9.44	a
Group D: Distilled water	65.33	12.55	b
Group E: No erosion	100.00	17.87	a

* Comparison between groups using ANOVA and Bonferroni post-test. Different letters represent groups with significant differences ($p < 0.05$).

Table 1 shows the mean and standard deviation values of the mineralization degrees obtained. ANOVA test determined that there were significant differences between groups, and Bonferroni post-test showed that the group of specimens subjected to erosive cycle and stored in distilled water presented significant differences with respect to the control group with no erosion ($p < 0.05$), while the other groups (Colgate Total®, MI Paste Plus and Salival® Solution) did not show significant differences with respect to the control group.

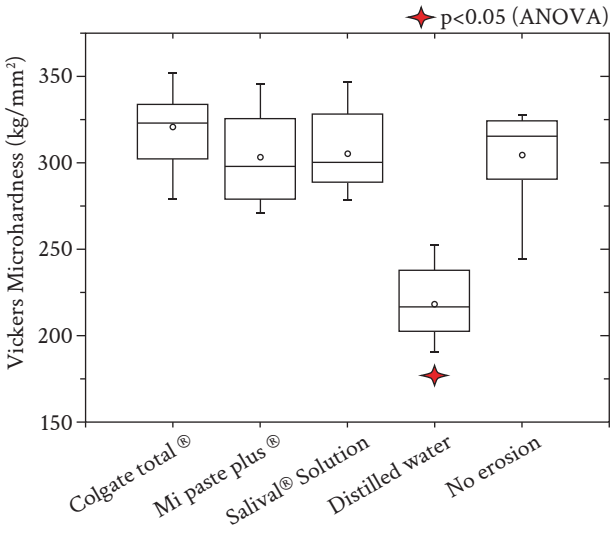

Figure 2. Box plot of Vickers microhardness in the groups studied. The star indicates the group with significant differences with respect to the others at 0.05 level.

Figure 2 shows the box plot for surface microhardness, in which, similar to the previous case, ANOVA test determined that there were significant differences between the groups; and by means of Bonferroni post-test it could be seen that the group of specimens subjected to erosive cycle and stored in distilled water presented microhardness values with significant differences with respect to the control group with no erosion ($p < 0.05$). On the other hand, the other groups (Colgate Total®, MI Paste Plus® and Salival® Solution) showed no significant differences in comparison with the control group.

Table 2. Descriptive statistics of the Vickers microhardness results obtained in the groups studied.

	Vickers microhardness (kg/mm^2)		
	Mean	**SD**	*
Group A: Colgate Total®	319.60	21.63	a
Group B: MI Paste Plus®	302.99	25.16	a
Group C: Salival® Solution	305.51	21.67	a
Group D: Distilled water	218.51	20.81	b
Group E: No erosion	303.71	27.52	a

* Comparison between groups using ANOVA and Bonferroni post-test. Different letters represent groups with significant differences ($p < 0.05$).

Mean and standard deviation values are presented in Table 2. In addition, Table 3 shows the HLP. It can be observed that group D subjected to erosive cycle and stored in distilled water loses 28.48% of surface microhardness significantly compared to the control group without erosive cycle.

Table 3. Values of hardness loss percentage (HLP) with respect to samples with no erosion.

	HLP **(%)**
Group A: Colgate Total®	4.61
Group B: MI Paste Plus®	–0.82
Group C: Salival® Solution	7.21
Group D: Distilled water	–28.48
Group E: No erosion	0.00

DISCUSSION

The objective of this study was to evaluate *in vitro* the remineralizing effect of synthetic saliva by assessing the degree of enamel mineralization and surface microhardness, using bovine enamel previously subjected to an erosive cycle. We found that the

effect produced by Salival® Solution synthetic saliva is similar to Colgate Total® and MI Paste Plus® commercial toothpastes.

A remineralizing agent can be defined as a substance capable of promoting remineralization of dental tissue (15). Saliva is the natural remineralizing agent par excellence (7) and, at the same time, a key vehicle for promoting enamel remineralization through other remineralizing agents. Under physiological conditions, it efficiently maintains the equilibrium between the dental substance and the biofilm. In adverse conditions, when pH tends to decrease due to a deficient removal of biofilm or ingestion of sugars, it seeks to reverse the demineralization process. Demineralization is a reversible process. Therefore, partially demineralized hydroxyapatite (HA) crystals in teeth can grow up to their original size if exposed to oral environments that favor remineralization (16).

Saliva contains minerals such as calcium and phosphate in adequate concentrations to remineralize tooth enamel. These minerals are deposited on the surface of the enamel and help to strengthen it, compensating for the loss of minerals during demineralization (17-19). Several studies have shown that supersaturation of saliva substitute with calcium and phosphates significantly increases its ability to remineralize dental hard substances (17, 18). Also, fluoride supplementation appears to play an important role in the maintenance of the crystal structure (16-19). After an acid attack, the salivary fluid buffers the H+ produced by bacteria. When pH is higher than 5.5, remineralization naturally occurs, since saliva is supersaturated with Ca^{+2}, $PO4^{-}3$ and F^{-} with respect to the dental mineral (20).

Saliva has a basic pH that can neutralize the acids produced by bacteria in dental plaque. This helps to reduce acidity in the mouth and prevent demineralization of tooth enamel (7, 9-11).

In recent years, a remineralizing effect has begun to be demanded from saliva substitutes, as some of these have a pH considerably lower than the limit value under which demineralization of enamel (approximately pH 5.5) or dentin (approximately pH 6-6.5) is known to occur. However, several studies have shown that there is no definite correlation between the pH of a saliva substitute and its effect on dental hard tissues (9, 10).

The wide range of products currently available and the different pharmaceutical forms facilitate the choice of the most suitable product for each patient, but those with a neutral pH, with fluoride supplements and the highest possible calcium and phosphate content should preferably be recommended (11). According to Laboratorios Unidos S. A. (LUSA) specifications, Salival® Solution has in its composition per 100 mL: sodium chloride (0.084 g), potassium chloride (0.120 g), calcium chloride dihydrate (0.015 g), magnesium chloride hexahydrate (0.005 g), sodium carboxymethylcellulose (0.375 g), propylene glycol (4.000 g), methylparaben (0.100 g), propylparaben (0.010 g) and purified water q.s. (100.00 mL).

Saliva contains enzymes and antimicrobial proteins that can help control the growth of bacteria in dental plaque, which helps to prevent caries formation and maintain a healthy oral environment (7). On the other hand, some saliva substitutes contain polymers as basic substances, which seem to influence both demineralization and remineralization of dental hard tissues due to their film-forming properties. Moreover, mucins and carboxymethylcellulose may bind calcium and thus limit the remineralizing power of a saliva substitute (12, 21-23).

In this study, the remineralizing effect achieved by Salival® Solution does not differ significantly from the initial situation prior to the onset of the acid cycle, achieving enamel remyelination. On the other hand, it contrasts significantly with the control sample that was preserved in distilled water, where the strong demineralization produced by citric acid is noticeable.

While fluoride-mediated remineralization is the cornerstone of current caries management philosophies, new strategies have been marketed or are being developed. These strategies claim to promote deeper remineralization of lesions, reduce the potential risks associated with high-fluoride oral care products, and facilitate lifelong caries control. These non-fluoride remineralizing systems can be classified into biomimetic enamel regenerative technologies and approaches that repair caries lesions by enhancing the efficacy of fluoride (24).

On the market, we find fluoride toothpastes, but there are also remineralizing dental products without fluoride. Currently, most commercially available non-fluoride remineralizing systems are intended to enhance the efficacy of fluoride, minimizing the potential risks associated with fluoride. These formulations are a promising alternative; however, it is necessary to investigate and characterize their remineralizing capacities. These studies are especially necessary for products that are already on the market, such as nanohydroxyapatite (nHA), casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), tricalcium

phosphate, calcium sodium phosphosilicate, amorphous calcium phosphates (ACP), polyphosphates, and sodium trimetaphosphate (24).

The results of this study comparatively show with commercial pastes that the effect of the use of artificial saliva used confers similar effect to that obtained by fluoride toothpastes and CPP-ACP, from the point of view of enamel remineralization.

The results show greater remineralization in the group exposed only to synthetic saliva. We should mention that the samples subjected to the toothpastes had a brushing process after each acid attack before being subjected to artificial saliva, and that the use of the electric toothbrush may have generated some additional loss of minerals, in relation to mechanical brushes (25, 26).

Carey (27) evaluated *ex vivo* remineralization in human teeth using SalivaMAX® artificial saliva supersaturated with calcium phosphate and obtained a marked increase in remineralization that provides relief from xerostomia and mucositis, allowing them to remineralize early enamel lesions without the requirement for acid pH cycling.

These findings show that the use of Salival® Solution artificial saliva is effective for enamel remineralization under *in vitro* conditions and could potentially complement the activity of toothpastes.

As limitations of this *in vitro* study, we can mention that, although the methodology standardizes the use of artificial saliva for all samples, it does not consider the variations that could occur in oral physiology and in the particular characteristics of the saliva present in individuals, so in light of the results, it is recommended to complement this study with *in vivo* and clinical studies.

CONCLUSION

Salival® Solution synthetic saliva has a remineralizing potential on eroded bovine enamel.

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Level of anxiety and dental pain at different times in root canal treatment during the COVID-19 pandemic

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ABSTRACT

Objective: To evaluate the level of dental anxiety (DA) and dental pain (DP) at different times in root canal treatment during the COVID-19 pandemic. **Materials and methods:** Observational, descriptive, and longitudinal study. The sample consisted of 68 participants from the Stomatology Clinic of the Hospital Militar Central (HMC), who met the inclusion and exclusion criteria. The procedure consisted of recording the level of AD and DP of the patients at different times during root canal treatment using a visual analog scale (VAS). **Results:** Before the procedure, participants showed 3.66±1.83 of DA and 4.54±1.79 of DP; during the procedure, they obtained values of 3.13±1.96 and 2.09±1.39 of DA and 2.96±1.57 and 1.82±1.09 of DP; and at the end of the procedure, they had 0.75±0.74 of DA and 0.53±0.72 of DP. **Conclusions:** DA and DP were found to be present before starting treatment, but as the procedure progressed their levels decreased.

Keywords: dental treatment anxiety, odontalgia, root canal treatment, COVID-19.

INTRODUCTION

Coronavirus 2019 or COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (1-3). Its clinical features are varied, ranging from asymptomatic cases to clinical conditions such as respiratory failure, systemic and multi-organ manifestations leading to death (4). In Peru, the preventive measure ordered by the government was quarantine. In that context, people in isolation during quarantine present a higher prevalence of psychological harm, including higher levels of anxiety compared to those who are not in such a situation (5).

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Anxiety has been defined as an emotion experienced in threatening situations, where "the mental state of fear is accompanied by physiological changes that prepare people for defense or flight, such as increased heart rate, blood pressure, breathing, and muscle tension" (6). In that sense, different life events may be involved in the occurrence of anxiety episodes. One of them can be attributed to traumatic dental events during childhood (7), which is known as dental anxiety (DA), defined as "an emotional state of worry in anticipation of a certain feared stimulus of dental treatment" (8). Several factors can influence DA levels, such as age, gender, previous treatment experiences, or pain during dental visits (7, 9-11).

When we talk about experiences prior to any dental treatment, we include diagnostic or therapeutic procedures conducted in dental offices. These can be stressful for patients, as they will be continuously exposed to auditory stimuli, such as metal sounds from instruments, high-speed piece noises, as well as sharp instruments (12). These stimuli are precisely present in root canal treatments, so patients undergoing root canal treatment may have some level of anxiety related to the procedure itself or to negative experiences from family and friends (13). Patients associate these episodes with fear and pain and anticipate this event as a negative experience. Historically, DA and pain expectancy have been related (9).

Pain is "a multidimensional phenomenon composed of physiological and psychological variables associated with actual or potential tissue damage" (14). Thus, odontalgia or dental pain (DP) is defined as an unpleasant sensory and emotional experience associated with dental tissues (15). It has been reported that patients with anxiety tend to have lower pain thresholds, especially in the oral cavity (11). Dental pain has been a very frequent emergency in dental care and, many times, the indicated therapy is root canal treatment. This process includes anesthesia, opening, pulp excision, canal shaping, cleaning, disinfection and obturation, which could cause fear of dental treatment in patients and, consequently, generate a certain level of anxiety (10).

DA and DP evaluations are important for the dentist as they help treat the patient and, in this way, anxiety and pain during root canal treatment decrease.

In that sense, the purpose of this study was to measure DA and DP at different moments in root canal treatment during the COVID-19 pandemic.

MATERIALS AND METHODS

The study was observational, descriptive and longitudinal. The sample included patients who were treated in the Endodontics area of the Cariology and Endodontics Service between February and July 2022. The sample selection was probabilistic and simple random. To determine the minimum proportion, a Fisterra statistical calculator was used with a confidence level of 90%, a margin of error of 10%, and a prevalence of 50%.

There were 68 patients who met the following inclusion criteria: over 18 years of age, who signed the informed consent, who had no history of previous root canal treatment, monoradicular teeth without radiographic periapical lesion; and patients diagnosed with any psychic alteration (13), pregnant women, intellectual deficit, visual decrease that did not allow the use of the visual analog scale (VAS), patients with retreatment or endodontic surgery (9), and those who consumed anxiolytics, antidepressants or antihypertensives (1) were excluded.

Data collection began on the day of the checkup. In the waiting room, patients were provided with an informed consent form in which they authorized their participation in the study. After that, a (VAS) scale related to DA and DP (t1: in the waiting room, preoperative time) was given, where participants marked with an X the levels of anxiety and pain present in that moment, ranging from "totally calm and relaxed" to "worst imaginable fear" and "absence of pain" to "intense pain", respectively. The obtained score determined the DA and DP present before root canal treatment.

During the root canal procedure, two VAS measurements were used at two different times (t2: after the canal opening; t3: after the biomechanical preparation; both considered intraoperative times), where the same process of marking with an X on the scale was followed, obtaining the results of this evaluation time. After the treatment (t4: after removal of absolute isolation, postoperative time), a new VAS was used, obtaining the levels of DA and DP at the end of the procedure. Root canal treatments were administered by postgraduate students supervised by medical doctors from the Endodontics area of Hospital Militar Central (HMC). The study was conducted after receiving approval from the Institutional Ethics Committee of Universidad Peruana Cayetano Heredia (CIE-UPCH) on January 26, 2022. Participants' information has been kept confidential.

Data were processed in SPSS version 25. Absolute and relative frequencies were used for qualitative variables (time of evaluation, life stage, sex) and measures of central tendency (mean and median) and dispersion (standard deviation, minimum, maximum) for quantitative variables (dental anxiety, dental pain). The corresponding tables and graphs were made from these data. After evaluating the assumptions (normal distribution, homogeneity of variances), it was decided to apply the Friedman test. After that, the Nemenyi *post hoc* test was applied. All statistical tests were used at a confidence level of 0.95 and a significance level of 0.05.

RESULTS

In this study, 68 patients (16 women and 52 men) participated with a mean age of 27.85 years (18-59 years). Before root canal treatment (t1), women obtained a DA level of 4.25 ± 1.80, while in men it was 3.48 ± 1.82. During the procedure, women presented a DA level of 3.56 ± 1.96 (t2) and 2.06 ± 1.12 (t3). In contrast, in men it was 3.00 ± 1.96 (t2) and 2.10 ± 1.47 (t3). At the end of the treatment (t4), women showed a DA level of 0.63 ± 0.50, while men showed a level of 0.79 ± 0.80 (Table 1).

Table 1. Comparison of dental anxiety by evaluation times according to sex.

Sex	Treatment	n	Mean	SD	Friedman's x^2	p
F*	t1[a]	16	4.25	1.80		
	t2[b]	16	3.56	1.96		
	t3[c]	16	2.06	1.12		
	t4[d]	16	0.63	0.50	42.6	<0.001
M*	t1[a]	52	3.48	1.82		
	t2[b]	52	3.00	1.96		
	t3[c]	52	2.10	1.47		
	t4[d]	52	0.79	0.80	118.0	<0.001

* Overall analysis with Friedman's test and pairwise analysis with Wilcoxon rank. Different letters represent groups with statistically significant differences ($p < 0.05$).

Before root canal treatment (t1), women presented a DP level of 4.75 ± 1.84 and in men it was 4.48 ± 1.67. During the procedure, women obtained a DP of 3.13 ± 1.66 (t2) and 1.81 ± 0.98 (t3), while in men it was 2.90 ± 1.56 (t2) and 1.83 ± 1.13 (t3). At the end of treatment (t4), women showed a DP level of 0.50 ± 0.63 and in men it was 0.54 ± 0.75 (Table 2).

Table 2. Comparison of dental pain by evaluation times according to sex.

Sex	Treatment	n	Mean	SD	Friedman's x^2	p
F*	t1[a]	16	4.75	1.84		
	t2[b]	16	3.13	1.66		
	t3[c]	16	1.81	0.98		
	t4[d]	16	0.50	0.63	42.5	<0.001
M*	t1[a]	52	4.48	1.67		
	t2[b]	52	2.90	1.56		
	t3[c]	52	1.83	1.13		
	t4[d]	52	0.54	0.75	137.9	<0.001

* Global analysis with Friedman test and Wilcoxon rank peer analysis. Different letters represent groups with statistically. Different letters represent groups with statistically significant differences ($p < 0.05$).

With respect to life stage, before root canal treatment (t1), the level of DA in young people had a level of 3.88 ± 1.97; and in adults it was 3.36 ± 1.59. During the procedure, young people obtained a DA level of 3.30 ± 2.06 (t2) and 2.20 ± 1.48 (t3), while in adults it was 2.89 ± 1.81 (t2) and 1.93 ± 1.24 (t3). At the end of the procedure (t4), young people had a DA level of 0.68 ± 0.73 and adults had a DA level of 0.86 ± 0.75 (Table 3).

Table 3. Comparison of dental anxiety by evaluation times according to life stage.

Age	Treatment	n	Mean	SD	Friedman's x^2	p
18-29*	t1[a]	40	3.88	1.97		
	t2[b]	40	3.30	2.06		
	t3[c]	40	2.20	1.48		
	t4[d]	40	0.68	0.73	95.2	<0.001
30-59*	t1[a]	28	3.36	1.59		
	t2[b]	28	2.89	1.81		
	t3[c]	28	1.93	1.24		
	t4[d]	28	0.86	0.75	65.2	<0.001

* Overall analysis with Friedman's test and pairwise analysis with Wilcoxon rank. Different letters represent groups with statistically significant differences ($p < 0.05$).

Table 4. Comparison of dental pain by evaluation times according to life stage.

Age	Treatment	n	Mean	SD	Friedman's x^2	p
18-29*	t1[a]	40	4.50	1.76		
	t2[b]	40	2.93	1.50		
	t3[c]	40	1.78	1.12		
	t4[d]	40	0.45	0.71	107.9	<0.001
30-59*	t1[a]	28	4.61	1.64		
	t2[b]	28	3.00	1.70		
	t3[c]	28	1.89	1.06		
	t4[d]	28	0.64	0.73	72.7	<0.001

*Overall analysis with Friedman's test and pairwise analysis with Wilcoxon rank. Different letters represent groups with statistically significant differences ($p < 0.05$).

At the same time, young people before root canal treatment (t1) presented a DP level of 4.50 ± 1.76, and in adults it was 4.61 ± 1.64. During the procedure, young people obtained a DP level of 2.93 ± 1.50 (t2) and 1.78 ± 1.12 (t3), and in adults it was 3.00 ± 1.70 (t2) and 1.89 ± 1.06(t3). At the end of the procedure (t4), the DP level in young people was 0.45 ± 0.71 and in adults it was 0.64 ± 0.73 (Table 4).

At the beginning of the treatment (t1), DA and DP presented a level of 3.66 ± 1.83 and 4.54 ± 1.96, respectively; however, as the procedure progressed, the results of both decreased, showing levels of 3.13 ± 1.96 and 2.09 ± 1.39 at t2, and 2.96 ± 1.57 and 1.82 ± 1.09 at t3. At the end of the treatment (t4), the following DA and DP levels were obtained, respectively: 0.75 ± 0.74 and 0.53 ± 0.72.

We compared DA at evaluation times using Friedman's nonparametric test and observed significant differences ($p = 0.001$). To identify between which groups there were significant differences, the Nemenyi *post hoc* or multiple comparisons test was applied, which determined that these differences occurred between times t1 vs. t3, t1 vs. t4, t2 vs. t3, t2 vs. t4, t3 vs. t4. On the other hand, when comparing DP in evaluation times by means of Friedman's non-parametric test, significant differences were also observed ($p = 0.001$); and, when applying Nemenyi's *post hoc* test, it was observed that these occurred between times t1 vs. t2, t1 vs. t3, t1 vs. t4, t2 vs. t3, t2 vs. t4, t3 vs. t4 (Table 5).

Table 5. Comparison of anxiety and dental pain by evaluation times.

Variable	Treatment	n	Mean	SD	Friedman's x^2	p
Dental anxiety*	t1[a]	68	3.66	1.83		
	t2[b]	68	3.13	1.96		
	t3[c]	68	2.09	1.39		
	t4[d]	68	0.75	0.74	160.3	<0.001
Dental pain*	t1[a]	68	4.54	1.70		
	t2[b]	68	2.96	1.57		
	t3[c]	68	1.82	1.09		
	t4[d]	68	0.53	0.72	180.3	<0.001

Nemenyi *post hoc* test (dental anxiety)

	t1	t2	t3
t2	0.11644	---	---
t3	5.9e-14**	0.00059**	---
t4	3.8e-14**	3.6e-14**	1.7e-05**

Nemenyi's *post hoc* test (dental pain)

	t1	t2	t3
t2	2.7e-05**	---	---
t3	6.4e-14**	0.0039**	---
t4	2e-16**	8.7e-14**	5.1e-05**

* Overall analysis with Friedman's test. Different letters represent groups with statistically significant differences ($p < 0.05$).
** Nemenyi *post hoc* test (statistical difference: $p < 0.05$).

DISCUSSION

Over the years, dentists have understood the importance of patients' perception of anxiety in relation to dental procedures (16), among which root canal treatment is one of the procedures that generates the highest level of anxiety (7, 11, 12, 17-20). DA has been associated with pain and occurs with greater incidence in invasive treatments, such as extractions and non-surgical root canal treatment (7, 21, 22). The emergence of the COVID-19 pandemic increased reactions of fear, anxiety, and psychological stress due to the increase in new cases reported every day and the high mortality rates resulting from the increased spread of the virus (23).

In this regard, we could think that patients' levels of DA and fear would increase due to the fear of contagion added to the anxiety they would already have due to the procedure itself. However, the results of this study differ from this premise, as patients did not report high levels of DA in comparison with other studies conducted in a non-pandemic setting, such as that of Coolidge et al. (24) and the meta-analysis by

Khan et al. (7), where participants similarly did not report high levels of DA, except in the preoperative stage. There are two reasons for this: 1) most of the study participants, being members of the Army, already had the vaccine inoculation; and 2) the HMC Stomatology Clinic followed all biosecurity protocols which increased their safety with respect to the risk of virus transmission.

The level of DA was evaluated according to sex at different operative times. Differences were found between both sexes just before starting root canal treatment, with women presenting higher levels of anxiety compared to men. This result is consistent with the study conducted by Wali et al. (25), in which women were classified as "highly and severely anxious" before root canal treatment, while men were classified as "without anxiety". One explanation for these gender differences in anxiety could be that women express their fears more freely when taking tests or surveys, based on the different social roles and expectations for each gender assigned culturally and traditionally (26).

With respect to the evaluation of the DA level according to age at different operative times, it was found that, during treatment, anxiety levels decrease as people get older. Similar results were obtained by Caltabiano et al. (22), who concluded that anxiety decreases with age. This could be due to the experience gained over time in different invasive treatments, which allows patients to develop tolerance and thus reduce anxiety with age. However, studies conducted by Del Pozzo et al. (21), Monardes and Peña (26), and Dou et al. (10) showed no significant differences in terms of age. This is because the minimum age in these studies was 18 years and older, and high levels of anxiety occur mainly in adolescence (21).

Many studies have investigated preoperative and postoperative anxiety, as is the case of Rosas et al. (17), Del Pozzo et al. (21) and Wali et al. (25), but few have analyzed it intraoperatively, as it was done in this study. Taking into account that the intraoperative time is when the patient is exposed to more auditory and visual stimuli, such as the sensation of suffocation caused by the use of the rubber dam (12), the fear of radiation when taking radiographic films (27) and the instrumentation of the root canal, it could be thought that the level of anxiety would increase at this stage compared to the times before and after treatment. Taking as a reference the scale used by Georgelin-Gurgel et al. (28), in which a value greater than or equal to 3 in VAS determines the presence of anxiety, the presence of anxiety was found only in one of the intraoperative times, which includes the anesthesia and the canal opening. The same results were found by Hamedy et al. (27), during the same procedures followed: use of local anesthetics and canal opening, thus increasing the anxiety level of their patients. This can be attributed to the patient's high speculation about the treatment, while at the end of the treatment there was no anxiety, possibly because the treatment is less invasive and painless than initially expected, which reduces the initial speculation (11).

On the other hand, the assessment of DP was also performed with VAS. When evaluating the level of DP according to sex, women obtained higher DP values. This is consistent with previous findings where women reported more intense pain than men (9, 29). Watkins et al. (29) attribute this to women anticipating sensory pain more than men due to greater autonomic arousal. Unruh (30) researched the impact of gender on pain assessment and reported that women tended to report more intense pain located in the head and more somatic problems. Liddell and Locker (31) reported a reduction of pain thresholds in women. At the same time, there is a higher level of mechanical allodynia in women with irreversible pulpitis and symptomatic apical periodontitis (32).

With respect to the evaluation of DP according to age at different operative times, it was found that adults presented DP before and during treatment. This finding is related to studies such as that of Gomes et al. (33), where age was significantly associated with preoperative pain, with younger individuals (<60 years) having a higher incidence of moderate/severe pain. However, there are no conclusive data that progressive loss of sensitivity to nociceptive stimuli occurs with age, and it has been suggested that age-related decline in pain may not be attributable to changes in the physiological system of pain (34).

DP was also evaluated at different operating times. Prior to treatment, participants presented DP, which is comparable to the results of Rosas et al. (17) and Pak and White (35), where they showed a moderate to severe level of pain. This could be due to the initial diagnosis they presented, such as irreversible pulpitis and/or symptomatic apical periodontitis. However, it was observed that DP was gradually decreasing. At the end of the treatment, the pain decreased. This result is similar to that obtained by Rosas et al. (17), where, before the endodontic treatment, 50.6% of patients reported a high level of pain, and at the end of treatment, 59.1% reported no pain at all. Previous studies of post-operative pain, such as

that of Perković et al. (36), relate it to endodontics procedures performed in one session, obturation materials and techniques, use of medication, and presence of preoperative pain.

Among the limitations, the sample could not be homogeneous among age groups or gender, since they were attended according to how they were referred by the oral medicine service, especially in the context of the pandemic in which this study was conducted.

CONCLUSIONS

DA levels present at the start of treatment decrease as the root canal procedure is performed. Similarly, the initial DP level disappears when the root canal treatment is completed. Women had higher DA and DP values in comparison with men. Finally, according to life stage, the DA level was present in young people and DP was present in adults.

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REVIEW ARTICLE

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Premolars with three root canals

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ABSTRACT

The root canal system is complex. In it we can find dental pieces such as premolars, whose internal anatomy is variable. Thus, in the upper premolars three channels predominate, while in the lower premolars there is a lower percentage of incidence. Nowadays, the use of CT scans is indispensable since they provide us with three- dimensional images that help us to generate a correct diagnosis, guarantee an adequate procedure and achieve the best favorable prognosis for endodontics. The purpose of this review article is to summarize information in a manual search of different scientific research articles from PubMed and Google Scholar, where the anatomical variations, diagnosis, and treatment of premolar teeth with three canals will be described.

Keywords: three canals, premolars, computed tomography.

INTRODUCTION

During the root canal treatment of premolars, one should always consider the different variations in root canal morphology, which can be attributed to a number of factors including racial origin, sex and age. An anatomical variation of premolars is the presence of three roots with three canals, which is more common in the upper first premolars and in men (1).

When premolars have wider crowns in the mesiodistal direction, they may present multiple roots. The opening of premolars with three canals will have a triangular shape for better access and visualization of the canals. It is estimated that the first upper premolar has three canals in 6%, while the second upper premolar in 1%, followed by the lower premolars in 0.5% (2).

The use of radiographs is indispensable, but they are not accurate, since they provide a two-dimensional image. Currently, reduced-field computed tomography scans are recommended because they are more accurate and provide three-dimensional (3D) images, which helps in the diagnosis and treatment plan (3, 4).

In this literature review, we will address basic and current concepts of premolars with three root canals, diagnosis, and treatment in order to provide a clinical scope for their correct approach and thus favor the prognosis of the treatment.

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PREMOLARS WITH THREE CANALS

Premolars with three canals generally have a variable morphology with three canals most frequently found in the upper first premolars. These have a similar anatomy to those of the upper first molar since they can present a palatine canal and two vestibular canals, classified according to Vertucci as type VIII (5) (Figure 1).

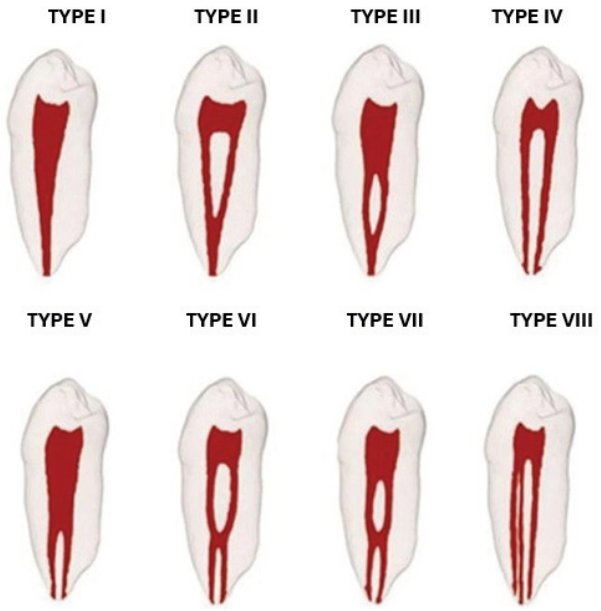

Figure 1. Anatomy configuration according to Vertucci. Image obtained from Jain et al. (5). Type I: Single canal. Type II: Two canals start and join in the apical third. Type III: a canal that divides into two canals in the middle third and joins in the apical third. Type IV: Two separate canals. Type V: starts in one canal and ends in two. Type VI: two separate canals start, bifurcate in the middle third and separate into two canals at the level of the apical third. Type VII: one canal starts, separates into two, joins in the middle third and separates again into two canals. Type VIII: three separate canals.

There are other classifications of canals, such as C-shaped canals. One of them is the one of Fan et al. (6), who use five categories, where I and III are the most frequent (Figure 2). Moreno et al. (7) mention that C-shaped canals can also occur in 1.8% of the lower first premolars.

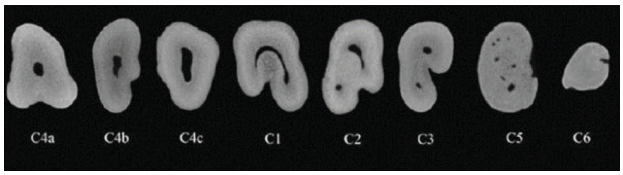

Figure 2. Axial section of a C-shaped canal. Image obtained from Fan et al. (6). C1: continuous C-shaped canal. C2: semicolon-shaped canal. C3: two or three separate canals. C4a: a single round canal. C4b: a single oval canal. C4c: a single flattened canal. C5: presence of more than three canals. C6: absence of lumen.

Another classification is that of Ahmed et al. (8), who use superscripts as follows: the superscript on the right side represents the number of roots; the superscript on the left side, the number of canals; the whole number, the tooth number; the letter B, the buccal canal; the letter L, the lingual canal; and the letter P, the palatal canal (8) (Figure 3).

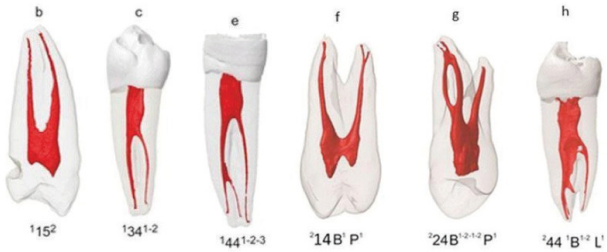

Figure 3. Anatomy configuration according to Ahmed et al. (8). 15 (Base number): tooth. Left superscript: number of roots. Right superscript: number of canals. B: buccal root. P: palatal root. L: lingual root.

The main characteristics of premolars will be described as follows.

Upper first premolar

The upper first premolars generally present two canals, with two apical foramina in 72%, considered according to Weine's classification as type III (Figure 4), and according to Vertucci's classification as type IV (Figure 1); and in a lower percentage we find three

roots with three canals, classified according to Vertucci as type VIII (8, 9) (Figure 1).

When the upper first premolar has only one canal, the chamber opening will have an oval shape (flattened mesio-distally). In case it has two canals, it will have the shape of eight; and in case it has three canals, the opening will have a triangular shape like that of the upper first molar (9) (Figure 5).

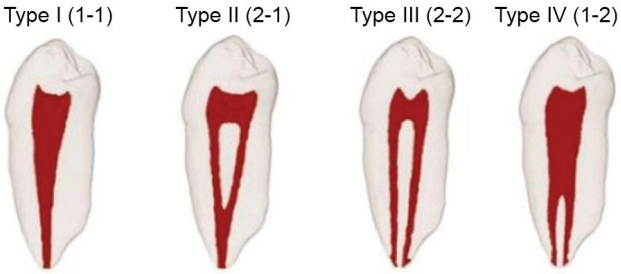

Figure 4. Anatomy configuration according to Weine. Image obtained from Ahmed et al. (8). Type I: single canal. Type II: two canals starting in the chamber and joining apically. Type III: two separate canals. Type IV: a canal that starts in the chamber and ends in two canals.

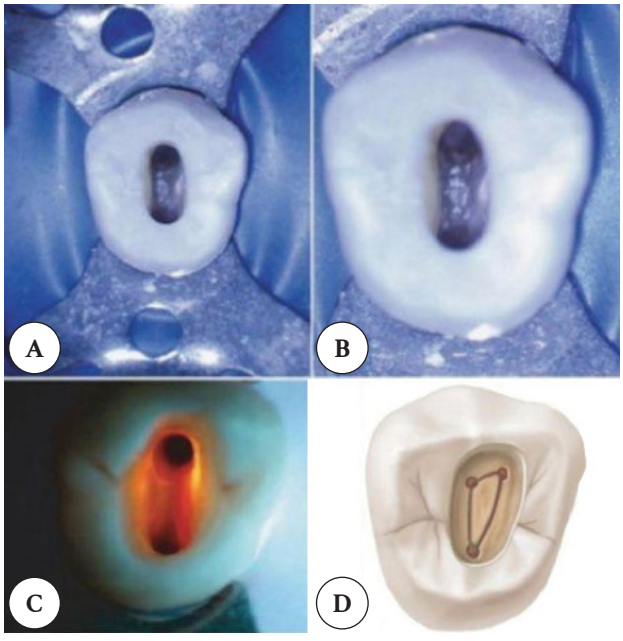

Figure 5. Chamber access of premolars in different magnifications. Image obtained from Cohen and Hargreaves (9). A: ×3,4. B: ×5,1. C: ×8,4. D: three-canal chamber access.

The upper first premolar can have: one canal with an apical foramen in 9%; two canals with a foramen at the apical level in 13%; two canals with two foramina at the level of the apical third in 72%; and three canals in 6% (10).

Upper second premolar

Regarding the anatomy of the upper second premolar, we can find that a higher percentage (75%) presents a canal with a single apical foramen; 24% has two canals with two foramina at the apical level; and a very low percentage of 1% presents three canals. When there are three canals, the shape of the chamber opening should be triangular, the same as the upper first premolar (10) (Figure 5).

When a root is found, it is wider in the vestibule-palatine direction than in the mesio-distal direction. The canal or canals remain oval from the floor of the pulp chamber and decreases at the level of the apex. The roots often resemble a bayonet shape, especially when they have proximity to the maxillary sinus (9).

Lower first premolar

Lower first premolars are usually more complicated to treat as they have a high rate of aggravation and failure. The possible explanation may be the wide variation in the root canal. Moreover, the access and location of the canal(s) are not easily traceable (9).

The lower premolars generally present in a higher percentage one canal with one apical foramen in 75.3%, two canals with one apical foramen in 6.5%, two canals with two apical foramina in 19.5%, and a lower percentage of 0.5% presents three canals. The opening of a canal will have an oval shape, as opposed to the opening of three canals that will have a triangular shape. Considering Vertucci's classification, types III and IV are the most frequent (9) (Figure 3).

At the same time, the lingual inclination of the crown tends to deflect the files in a vestibular direction. The inclination of the crown will make it even more difficult to locate the lingual canal. To find and have better access to this canal, the lingual wall must be widened (9).

The diagnosis and treatment of additional canals in the lower premolars is a challenge for clinicians. Not locating and obturating a canal will lead to treatment failure. Balakasireddy et al. (11) found a 42% incidence of failures in teeth that had additional roots or canals. They also found an incidence of the lower first premolar with three roots of only 0.2%, increasing this incidence to 18.1%.

Lower first premolar

The second lower premolar can present in a higher percentage one canal with one foramen at apical level in 85.5%, two canals with one foramen at apical level in 1.5%, two canals with two foramina at apical level in 11.5%, and three canals in 0.5% (10).

Although the lower second premolar is similar to the first one, there are some differences in the inner space of the crown, for example, it is occupied by a pulp horn on the lingual side, which is usually larger in the longitudinal direction. At the same time, the root and the root canal are more frequently oval. The pulp chamber is more extensive in the vestibule-lingual direction. And, usually, distance between the pulp chamber and the root canal can be distinguished, unlike the lower first premolar (9).

DIAGNOSIS

Knowing about the anatomy of the canal system is important to make a good diagnosis of premolars with three canals. Furthermore, it is necessary to take complementary examinations such as X-rays and cone-beam CT scans. Today, the latter are the most assertive because they have a three-dimensional image that helps us locate and differentiate the canals (12).

When taking conventional X-rays, different horizontal angulation of the X-ray beam can be used to observe more clearly the separation of the canals that are usually superimposed, since they present different morphologies of their external roots, for which the Clark technique and the triangular technique of radiological tracing by Bramante (13) are most frequently used.

1. **Clark Technique.** To perform the radiographic technique, two different periapical radiographs of the tooth to treat are required. The first is an ortho-radial radiograph, which is taken with a horizontal and vertical angulation, where it only facilitates the evaluation of the dental tooth in two dimensions (height and width). For a deep evaluation, the second radiograph is taken by angling the X-ray collimator in a mesio-radial direction. If the collimator is placed mesially or disto-radially, the collimator is placed distally (14).
2. **Bramante's triangular radiological scanning technique.** It is used to diagnose cases such as root curvatures, stair-stepped incision, perforations, the presence of fractured/separated instruments or calcified canals in a more accurate way (14).

Cone-beam computed tomography provides us with a three-dimensional image that will help us to locate the canals, as in the case of premolars with complex anatomy, and thus have a more accurate diagnosis to help in the treatment of these pieces in order to improve the result and reduce the possibility of making a false way or perforations (11).

CLINICAL MANAGEMENT

The clinical management of premolars with three canals is complex due to their different anatomical variations. Nowadays, for root canal treatment, magnification (magnifying glasses, microscope), biomechanical preparations with mechanized instruments (rotary, reciprocating) and ultrasonic irrigation are used and are very helpful (15).

When dealing with complex dental anatomy, passive ultrasonic irrigation (PUI) is a complementary technique that is used effectively because it helps to remove bacteria, detritus and smear from the canal system in an efficient way and superior to conventional syringe irrigation (15).

Studies have shown that anatomically complex root canal systems, such as three-canaled premolars, cannot be easily cleaned or effectively obturated. Cho et al. (16) introduced a new obturation technique, known as ultrasonic vibration and thermohydrodynamic obturation (VibraTHO). This technique incorporates high-temperature, short-time vertical compaction using a single cone of gutta-percha and is designed to use hydraulic pressure to induce hydrodynamic movement of the sealer into the root canal using ultrasonic energy, where the main component (single cone of gutta-percha) will be compacted.

The objective of canal obturation is to achieve a good three-dimensional seal. For this purpose, the selection of a suitable sealant material and the ideal obturation technique is important. Cold lateral compaction is the most common obturation technique used by the clinician administering the root canal treatment. It is also considered the gold standard in endodontics. Although predictable and relatively simple to execute, root canal obturation using a lateral compaction technique may lack homogeneity and therefore generate lots of space. Thermoplastic techniques, such as continuous wave condensation (CWC) and the Tagger's hybrid technique (THT), based on carriers (Thermafill system), have been developed to incorporate the use of thermal or frictional heat to obtain thermoplastic gutta-percha molds that

allow advantageous results for the management of irregularly shaped root canals, which in turn allow better adaptation to the canal walls, with a more homogeneous filling (17).

The single cone (SC) technique is currently widely used due to its ease of execution. It is less sensitive to operator variations, has a low cost and a short operating time. This technique uses a gutta-percha cone with a diameter similar to the last instrument used to shape the root canal. However, it demands a larger amount of sealer, so the fluidity and other physicochemical properties of the sealer play a fundamental role in the success of a root canal treatment (16).

Nowadays, there are bioceramic endodontic sealers, such as MTA/Bioceramic, Bio-C Sealer (Angelus, Brazil). These sealers contain calcium silicate, calcium aluminate and calcium oxide, which makes them biocompatible and bioactive due to the release of calcium ions. They also contain zirconium oxide, iron oxide, silicon dioxide and propylene glycol as dispersing agents, without shrinkage after setting. The mechanical and physical properties provide ease of handling and hermetic sealing of the canal filling. Bioceramic sealing cements can be used with the lateral compaction technique, single cone and thermoplastic sealing (according to the manufacturer's indications) (17).

Regarding the obturation of premolars with complex anatomy, such as those with three canals, it is known that it is difficult to obturate them completely. Therefore, it is essential to consider a homogeneous obturation that improves the treatment prognosis. The gutta-percha single cone technique could be considered advantageous due to the use of the bioceramic sealer that expands when it sets and leaves fewer spaces in the root canal (17).

Failures in the treatment of three canals

Failure in root canal treatment can be attributed to many factors such as lack of knowledge of canal anatomy, unfilled or incompletely debrided canals, persistence of bacteria, iatrogenic procedural errors, such as poor cavity conformation at the time of chamber opening, as well as complications at the time of biomechanical preparation (perforations or separate instruments) (18).

A study by Tabassum and Khan (19) presented 236 cases of three-canal premolar root canal treatment failures, all related to the presence of bacterial infections and periradicular rarefaction. Bacteria present in the periradicular area will be inaccessible to disinfection procedures. A poor apical seal is also a contributing factor to endodontic failure due to the persistence of microorganisms, which can lead to apical leakage.

Regarding the failure premolar treatment with three canals, this may be due to the omission of the search for the additional canal due to its low frequency of occurrence. For this reason, it is important to have a correct clinical and radiographic diagnosis prior to the beginning of the chamber opening. Without a proper diagnosis, ignoring the presence of a third canal could lead us to maintain a remnant pulp tissue within the unfound canal, thus generating the imminent failure of the root canal treatment. Knowledge of the symmetry law during opening will determine an existence of an additional canal (19).

DISCUSSION

Root canal systems are complicated and variable, which is why diagnosis and treatment is often a challenge. The root canal morphology with the highest incidence in premolars is formed by the presence of one canal. However, there is the possibility of two or three canals in a lower percentage (10).

Root canal cleaning is of utmost importance for a successful endodontic treatment. Periapical radiographs can be used from different angles as well as during treatment procedures to detect anatomical variations. Nevertheless, they may not provide complete information about the canals, as the resulting images are two-dimensional. With the diagnostic support of cone beam computed tomography for root canal treatment, it is possible to identify canals that cannot be seen on periapical radiographs obtained from different angles. Furthermore, the preparation of a correct chamber access and the clear identification of the chamber floor are also effective resources for the detection of additional canals (20).

Beyraghshamshir et al. (2), in their 2020 study, identified the canals using dental microscope magnification. They used the DG16 endodontic explorer to find the canals, and obturated with the single cone technique using a cone with 0.04 taper and Sure Seal Root bioceramic sealer. This demonstrated the need for the use of magnification (Figure 6).

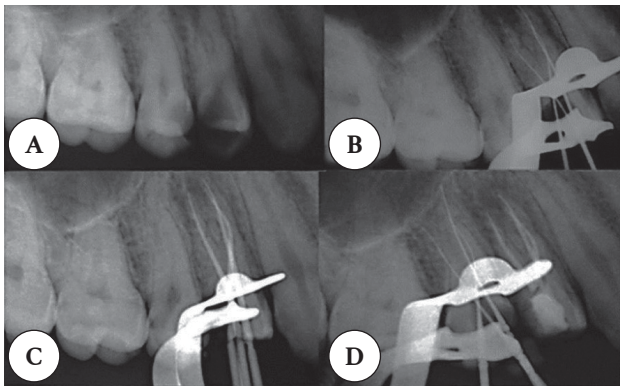

Figure 6. Root canal treatment sequence of an upper premolar. Image obtained from Beyraghshamshir et al. (2). A: A: diagnostic X-ray; B: conductometry; C: conometry; D: obturation of the three canals.

CONCLUSIONS

Before starting root canal treatment, variations in pulp anatomy and root morphology should always be considered. Clinical and radiographic examinations are essential for the success of the treatment; and nowadays we have significant help with tomography, since it helps us identify additional canals, atypical morphologies, among others, by providing a three-dimensional image.

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REVIEW ARTICLE

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Non-attendance at dental appointments: a brief review of causes and strategies for prevention

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ABSTRACT

Non-attendance at dental appointments is a relevant problem in health care due to the negative consequences it entails. This article aims to review the causes of nonattendance and the strategies implemented for its prevention at the international level. Socioeconomic, cultural, geographic, and demographic factors are identified as the main causes of absenteeism. An inversely proportional relationship has been observed between socioeconomic status and absenteeism, with those patients with greater resources tending to have lower absenteeism. Socioeconomic and cultural factors, together with oral health education, influence the concern and frequency of dental checkups. Various solutions have been proposed, such as telephone or SMS reminders, although their effectiveness may vary due to patient familiarity and access to technology. There is a need to address this problem comprehensively and consider different approaches to reduce missed dental appointments.

Keywords: non-attendance, dental care, inequity.

INTRODUCTION

There is little research in such a relevant area to improve care in the dental field such as the case of nonattendance to dental appointments. Every time someone does not attend a health care service, not only is the time allocated by the professional for this service lost, but another patient is deprived of the opportunity to use those hours. This is a problem both in the medical and in the dental area (1). In this area, the number of patients who do not show up (NS) for their appointments is even higher, making it a topic for research and search for solutions (1-7). The aim of this article is to review the causes of non-attendance at dental appointments and the strategies that have been implemented internationally for their prevention.

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CAUSES OF DENTAL NON-ATTENDANCE

In Chile, Oliva et al. (2) found that 65% of pregnant women enrolled in the Explicit Health Guarantees (GES) program between 2014 and 2015 missed at least one dental appointment. Of these, 23% would not have finished their treatment. In the search for relevant scientific information that supports the topic under study, it was evidenced that socioeconomic factors were the most influential, which are also related to cultural aspects that vary between geographic areas. Nevertheless, there are studies in which the subject is addressed in different aspects. The value of dental care as a health priority for people, both individually and collectively, relates to the culture of each population. This is observed when comparing the results of various studies on absenteeism to dental appointments, such as the one conducted by Listl et al. (3) in adults over 50 years old in 14 European countries. These authors found that, among the most common reasons for not attending dental appointments was the patients' perception of "not being as necessary," at a rate of 23-64%. Similarly, Armfield (4) found that, out of a sample of 1083 Australian adults, 67% avoided going to the dentist, where 21% did so due to the lack of interest and 12% said they "do not like the dentist". We can observe that attendance at dental checkups is influenced by the perceived importance given to oral health by the various communities.

In turn, absenteeism is influenced by socioeconomic and educational level, which varies even within the same country or population. It influences the commitment of patients to dental care and compliance with dental care appointments in various ways. This hypothesis has been studied by several authors. Crocombe et al. (5) determined that having belonged to a low socioeconomic stratum in childhood influences the habit of regularly attending the dentist. Therefore, they found that, of the 833 participants in their study, only 30% regularly attended dental check-ups.

On the other hand, Gallego et al. (6) determined that the socioeconomic factor affects the quality of oral health and the importance given by individuals. They found that disinterest was more frequent in women, and that this was correlated with the presence of small children in the home, which made it impossible for them to attend dental appointments. According to the authors, this probably occurs because these women are engaged in time-consuming and costly childcare activities, suggesting that people with young children may be a very important target for oral health policies.

Although the results of both studies (5, 6) reinforce the idea that socioeconomic factors influence the quality of oral health and compliance with dental appointments, they contrast with those obtained by Listl (7), who concluded that absences related to the cost of care in adults were not significant, since the range of absences for this reason was 0.5-6.8% of the total number of patients NS.

Along with the cultural and socioeconomic factors is the population's education in terms of oral health, which can be improved through health promotion campaigns. Education turns out to be a highly relevant factor when analyzing the reasons for non-attendance at dental appointments. The lack of regular check-ups and the low value placed on oral health are causes of non-attendance that are repeatedly observed in the results of multiple research studies.

Bhatia et al. (8) determined the number and some of the most common reasons for absence of children to their dental checkups in India. 54% of patients were in the age group 7 to 12 years. Among the most frequent reasons was the forgetfulness of the proxies and/or guardians (17%); a second reason was that the patient "did not have any symptoms" (12%), so it was unnecessary to attend. Something similar to this reality occurs in 12- and 13-year-old adolescents in New Zealand, where there was a 25% of patients NS because they had no symptoms, while 26% did not think about the dentist and 10% believed it was not important (9).

Along the same lines are the results obtained from a study of pregnant women in Nigeria, where only 7% had reported an appointment during pregnancy. The reason was presence of pain, apart from finding that 62% of women had never been to the dentist, who again attributed this to the absence of symptoms and pain. Moreover, younger women were the least likely to attend checkups compared to older women (10).

In Latin America, a study of pregnant women in Bolivia highlighted factors such as "fear of attending due to cultural beliefs" that do not correspond to people's typical fear of visiting the dentist. This is because in this item women cited "fetal malformations, miscarriages and fainting" (11), reasons that can be further investigated. Meanwhile, in Colombia, Lozano et al. (12) concluded that 45% of pregnant women mentioned reasons of accessibility such as lack of money, difficulty to transport, and the location of the hospital.

Apart from the various reasons for non-attendance at dental checkups mentioned by the many authors mentioned above, there are also several causes that are not directly attributable to socioeconomic, cultural or demographic factors, but that represent a significant number. There are also cases where other reasons are registered. For example, Tandon et al. (13) reported that, out of a sample of 2294 patients, between March and August 2014, 886 did not attend their dental checkups, of which 40% did not attend for the reason of "not being able to leave school", followed by 25% who were "not able to attend because they were sick". On the other hand, Gustafsson et al. (14) reported that Swedish adolescents living with single parents were more likely to miss their check-ups (14). In contrast, Vingilis et al. (15), in Canada, found higher attendance of adolescents who were children of single parents compared to children of married parents.

On the other hand, in Colombia it was found that non-attendance was related to the quality of care perceived by patients, who referred to the poor quality of the dental service as the reason for non-attendance at their appointments. Furthermore, they mentioned it was difficult to pay for transportation to attend, so a transportation subsidy was generated, and it decreased absences in 87% (16).

PREVENTION OF DENTAL NON-ATTENDANCE

To expose the problem of missed dental appointments, there are several studies that offer solutions to this problem. In a study conducted by Storrs et al. (17) in a dental school in Australia, factors for patient's non-attendance were evaluated. The data included appointment status (attended, canceled, or NS) and a number of demographic and time-related factors. Attendance rates were also compared by year after the implementation of a text message (SMS) reminder at the beginning of 2012. The results showed that, of 58 622 appointments booked with students during those years, 68% of patients were checked, 23% were canceled, and 9% were No Show (NS). Women were 7% less likely to mark NS. Those aged 16-24 were five times more likely to mark NS; and early morning appointments were 18% less likely to be canceled and mark NS. With the SMS reminder system, the odds of cancellation were 15% higher, but NS were 14% lower.

In the United Kingdom, Kirby and Harris (18) describe several strategies to reduce the number of missed pediatric appointments, like for example reminding the guardian by phone call and/or SMS, which helped to reduce no-shows and to keep track of patients by rescheduling appointments in a timely manner.

In Chile, a study by Garrido et al. (1) evaluated the implementation of a system for scheduling and reminding patients of appointments by phone calls. They observed not only a decrease in no-shows (from 24% to 21%), but also an increase in appointment scheduling due to the timely rescheduling of the hours of patients who did not attend, thus decreasing the number of free hours by up to 40% during some months. This improved the efficient use of human resources and cost for the health center where the strategy was implemented.

Bellucci et al. (19), in Australia, studied the rate of patients NS as well as patients following the implementation of SMS reminders in a public dental outpatient service over a period of 46 consecutive months. The authors found that the SMS intervention was not effective in reducing NS rates, unlike the literature on this measure, where the rate of patient attendance at outpatient clinics improves.

DISCUSSION

The analysis of the causes of non-attendance at dental appointments and the prevention strategies implemented at the international level has several important implications. First, socioeconomic and cultural factors have been identified as playing a significant role in dental appointment attendance. These factors influence the population's perception of the importance of oral health and their commitment to dental care. Therefore, interventions aimed at improving care should address these disparities and adapt to the specific needs and contexts of each population (3, 4, 6).

In addition, oral health education has been found to be a crucial factor in non-attendance at dental appointments. Lack of awareness of the importance of regular checkups and the value placed on oral health make patients avoid considering appointments as necessary, as they assume that the dentist is only necessary when there is damage or pain. Therefore, prevention strategies should include educational and health promotion programs that raise awareness and understanding of the importance of regular dental care (8-10).

Another relevant implication is the influence of the perceived quality of the dental service when attending appointments. Patients who experience a poor-quality service tend to avoid dental appointments. This

highlights the need to improve the quality of service and ensure a satisfactory patient experience, which may include additional training for dental health professionals and the implementation of measures to improve patient accessibility and comfort during appointments (16). Incidentally, there are limitations related to the cost of dental equipment and supplies, which in low-income contexts are difficult to afford. Nevertheless, it is possible to improve the perception of the service and its use through improvements in treatment, which are generally valued by patients.

Despite significant findings, it is important to recognize the limitations of the evidence presented. Thus, most studies have been conducted in specific countries and in particular contexts, which limits the generalization of results in other populations and settings. More research needs to be done in different geographic regions, and the specific causes and solutions to each local context need to be evaluated (20).

In addition, some studies show discrepancies in their results, suggesting that the determinants of dental appointment attendance may vary in proportion to different populations. This highlights the need for additional research to understand the specific causes of non-attendance in each population and to develop personalized intervention approaches (20).

Based on the implications and limitations of the evidence presented, the following recommendations for future studies are proposed:

1. To conduct research in different countries and settings to understand the causes of dental appointment non-attendance in diverse populations, and address existing disparities.
2. To thoroughly investigate the influence of socioeconomic and cultural factors on dental appointment attendance, including the impact of economic and geographic accessibility to attend appointments.
3. To conduct longitudinal studies that evaluate the long-term effectiveness of strategies to reduce absenteeism.
4. To innovate in the use of new information technologies, also making use of principles of social psychology to obtain a greater appreciation of dental services.
5. To generate interventions that include the participation of other health professionals, as well as social services, so that dental care is recognized by health and welfare services.

CONCLUSIONS

The influence of socioeconomic and cultural factors, as well as the oral health education of the population, are key elements that affect the concern and frequency of dental checkups, as highlighted in the research reviewed. Given the significant and complex problem of non-attendance at dental appointments, several studies that propose solutions have been conducted. These proposals mostly focus on phone or SMS reminders, although their effectiveness has been variable due to patient familiarity and access to technology.

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Dental digital impressions with intraoral scanners: a review of the literature

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ABSTRACT

Computer-aided design and computer-aided manufacturing (CAD-CAM) has been applied in dentistry for the preparation and analysis of various dental treatments. It starts with capturing images through intraoral scanners, having different types of software and image export systems and technology. The advantages of this digital workflow are the following: better adjustment, shorter clinical time, and speed in dental treatments, in addition to providing greater practicality for dental surgeons. The accuracy provided is clinically acceptable in comparison with conventional methods, so there is sufficient evidence for their validity; however, it should be taken into account that several factors can alter the result, such as the operator's experience, the type of scanner, the type of software, the software update, the scanning principle of the scanner, the environment, the scanning sequence, and the oral structures. The present review article aims to analyze the literature on the different characteristics and properties that intraoral scanners present today and the evidence of the potential benefits and accuracy of digital impression techniques versus conventional impression techniques.

Keywords: dental impression technique, dental impression materials, computer-aided design.

INTRODUCTION

Since the beginning of dentistry, conventional impression techniques have been required and used to register the oral cavity of patients in a three-dimensional way (1). However, volume changes of impression materials and the expansion of dental plaster are sensitive to erroneous results. At the same time, with the advancement of technology applied to dentistry (1), in the early 1980s, computer-aided design and computer-aided manufacturing (CAD-CAM) were developed (2), which was the first system of the commercial brand Cerec (Sirona). This

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has become increasingly important in dentistry, and excellent results have been obtained in the preparation of restorations with various materials (2). The three main components of a CAD-CAM system are the data acquisition unit (intraoral or extraoral scanner), the program software, and the milling or 3D printing device (3). This way, the digital workflow starts with intraoral scanning, expanding the availability of various scanning systems in recent years, operating according to different principles, including active triangulation, parallel confocal imaging, active wavefront sampling and stereophotogrammetry. On the other hand, more recent systems present combined principles (3).

Digital impressions are a clinically acceptable alternative to conventional impression methods, as digital dental technology has evolved, and their application extends from single crowns to complete rehabilitations and even implant support (3). However, there are still limitations as the accuracy of intraoral scanning can be influenced by scanner technology, operating system, device calibration, scanning pattern, ambient light scanning conditions, cutting and rescanning procedures, extent of digital scanning, characteristics of the structures to be scanned as tooth preparation, implant-supported restorations, and partial or total edentulous jaws (4). Additionally, digital impressions present advantages such as efficiency of clinical time in the dental chair, greater patient comfort, real-time viewing, easy communication with dental laboratories, and the versatility of a smoother and more accurate workflow (5, 6).

The aim of this review article is to analyze the literature on the different characteristics and properties of current Intraoral Scanners (IOS) as well as to evaluate the evidence of the potential benefits and accuracy of digital impression techniques versus conventional impression techniques.

INTRAORAL SCANNERS

Imaging with intraoral scanners

IOS are devices used to capture direct optical impressions of the oral cavity (7). They perceive the surface structure of different tissues and capture this 3D image through a laser that projects a light source onto the dental arches, prepared tooth surfaces, and adjacent tissues, while images are captured by sensors (8).

IOS are composed of a *handheld wand* that generates a light projection (active technology) to capture the image by a static (photos) or dynamic (videos) method, which will be put together by the software after recognizing the triangulation of 3D images (9). Triangulation is a technique in which a light source is reflected onto an object, the x and y coordinates of each point are registered, and then the z coordinate is calculated, all based on various optical imaging technologies (10).

Active confocal microscopy

It is a technique for obtaining images of specific depths. It detects the different areas of image accuracy to be able to estimate the distance between the object to be scanned and the focal length of the lens. After that, a tooth can be reconstructed with consecutive images acquired with different focal lengths and diaphragm values from different angles of the object's periphery (11). The area of accuracy is clearly linked to the user's experience, since some type of motion blur may occur. Apart from that, this type of procedure requires a long head, which may cause difficulties in the clinical practice (12).

Active wavefront sampling

It is an image collection technique that uses a camera and an off-axis aperture. The module has a movement where it follows a circular path around the optical axis, which generates a rotational movement of the specific point of location to be scanned (POI). From the pattern produced by each evaluated point, depth and distance data can be obtained (13).

The images captured by different sensors are processed by the scanner software that generates a set of vertices (point clouds). These are then triangulated to create a three-dimensional mesh model (7). Performance can be influenced by several factors, including IOS type, intraoral conditions, scanning protocols, scanned object geometries and surface optical properties, processing software algorithms, and ambient light conditions (14).

Types of software and image export systems and technology

Digital print data transfer systems using IOS can be classified into open systems and closed systems.

Open systems

They are systems where IOS software allows digital printing to be sent directly through the export of source files, which can be a standard data transmission format for making elements in 3D (STL) Standard

Tessellation Language or Standard Triangle Language, a Polygon File Format (PLY) or an Object File Format (OBJ) to different laboratory units, which gives the desired flexibility and allows maximizing the investment potential with different options (15).

The STL file format is simple and small, so its processing is faster, but without color or texture representation. On the other hand, OBJ and PLY formats can store properties such as color and texture that benefit enhanced 3D printers (7).

Closed systems

In a closed system, digital impressions are sent to the manufacturing company for a subscription fee. The advantage is that, since the configuration, data collection, and manipulation are used by the same manufacturer, there is greater security, accuracy and a single place for delivery. Some scanners only allow data acquisition, which is then sent to the laboratory for further processing and manufacturing. On the other hand, there are scanners that, in addition to acquisition, can mill or print the same day, allowing the patient to have a dental restoration in a single session (7, 16).

Data collection methods, image transfer, tracking strategies, and scanner head size may vary between different types and brands, but each procedure produces a digital model of the patient's dentition (9, 16).

Patient acceptance of the use of intraoral scanners

In some of the studies using irreversible hydrocolloid impression, patients preferred conventional impression, compared to a previous IOS generation, due to the difficulties in optical impression, regarding operability, scanner size, scanning speed, etc. However, due to improved hardware technology, the scanning speed has improved, and the size of devices has been reduced, optimizing their ergonomics (1-6). Therefore, in recent research, many patients responded that IOS was more comfortable, especially when it is necessary to repeat some dental impression with the conventional technique, which would mean more time with the patient in the dental chair and the use of extra material. Furthermore, an additional benefit is that the gag reflex would be minimized. Some studies use irreversible hydrocolloid impressions as a comparison since they are easier to control than elastomeric impressions (3). As a result, when comparing IOS with conventional impressions, the first one presents superior qualities and results with respect to patient acceptance (1-7).

Operator satisfaction

Schlenz et al. (10) and Lam et al. (11) demonstrated that there was a significantly higher proportion of students who perceived that IOS require less armchair support and it is easier to master as a beginner. In addition, 60.2% of students had no difficulty to operate the scanner software, so the scanning process was manageable (11).

Accuracy of digital impressions made with intraoral scanners

Accuracy of impression methods is critical for the internal and external adjustment of indirect restorations. Accuracy is the difference between the quantitative values obtained from the measurement and the actual spatial values of the measured object, and, in turn, comprises trueness and precision. Trueness means how close the results of a measurement are to the actual values of the measured object, while accuracy is the variability of repeated measurements of the measured object (7). The higher the accuracy, the more reliable the measurement; and the higher the trueness, the closer the measurement is to the actual dimensions of the object. The methods for comparing the accuracy of digital and conventional impressions are linear measurement and 3D superimposition. Compared to linear measurement, 3D superimposition evaluates hundreds of measurement points, which may reflect the deformation of the entire dental arch (11).

The accuracy of a digital scan depends on the ambient light, the size of the scanner head, the scanning technology, whether reflective powder is required, the scanner software program, the scanning protocol, the limited space in the buccal opening, the length of the edentulous section, among others (5). Therefore, to evaluate the adjustment of restorations when using IOS systems, two-dimensional or three-dimensional indirect approaches can be used (4-6). Internal marginal discrepancies of less than 120 μm have been described as clinically sufficient for the fitting of single-tooth restorations (2). Despite this, the American Dental Association suggests that the thickness of cementation do not exceed 40 μm (2, 17). Hence, this acceptability limit is not yet defined, and inadequate marginal/internal adaptation may predispose to

restoration failure. When assessing the final fit, factors such as CAD design, CAM milling process and seating of the restoration, and preparation geometry should all be taken into account because the existing literature advocates that the more complex the scanned morphologies are, the more difficult it is to reproduce them in digital form and, consequently, there could be a detrimental effect on accuracy (3, 15, 18).

Poor marginal fit can promote biofilm buildup and cause complications, such as secondary caries and periodontal disease, and poor internal adaptation can lead to periodontal loss of axial retention, lack of rotational stability, reduced fracture toughness and positioning inaccuracies, which lead to interproximal and occlusal interferences (3-8).

Scanner (Brand name)	Scanning principle	Size	Price	Integrated screen	Open system
Trios 4 (3Shape)	Confocal microscopy	Small	💲💲💲	No	Yes
Trios 3 (3Shape)	Confocal microscopy	Small	💲💲	No	Yes
PrimenScan (Dentsply Sirona)	Active triangulation and confocal microscopy	Medium-sized	💲💲💲	Yes	Yes
Omnicam (Dentsply Sirona)	Active triangulation	Medium-sized	💲💲	Yes	Yes
Cs3600 (Carestream)	3D active speed video	Medium-sized	💲💲	No	Yes
Cs3500 (Carestream)	Optical triangulation	Medium-sized	💲💲	No	Yes
iTero Scanner (Align Technology)	Parallel confocal microscopy	Medium-sized	💲💲💲	Yes	Yes
i500 (Medit)	Active triangulation	Medium-sized	💲💲	No	Yes
i700 (Medit)	3D motion video technology / Fullcolor 3D broadcast capture	Medium-sized	💲💲	No	Yes
Virtuo Vivo (Dental Wings)	*"Orthographic projection"*	Small	💲💲	No	Yes

Figure 1. Comparison of intraoral scanners according to their characteristics

In addition, the manufacturer of each scanner specifies a scanning strategy, although for each full arch it does not mention the starting quadrant. In general, newer scanners, Trios 4 and Primescan provide more accurate data for full-arch digital impressions. However, up to the moment there is no evidence of relevant differences in performance between the various digital scanners that are clinically relevant. This, on the one hand, may be due to continuous advances in hardware development and/or software upgrades. For the Cerec systems, the software version had a significant impact on IOS accuracy. And for the Trios scanner, the hardware also has a significant influence on the transfer accuracy of full-arch scans (1, 17).

Comparison between digital impressions and conventional impressions

Dental impressions can be conventional or digital. Conventional impressions refer to the negative impression of the tooth surface and adjacent structures. Nowadays, the most used materials for this type of impressions are irreversible hydrocolloids and elastomers (1, 5, 16).

With the advent of IOS, interest in digital impressions obtained directly from intraoral scanning has been increasing (4, 5). Compared to conventional impressions, digital impressions generated by IOS have several advantages. However, conventional

impressions and plaster models have always been considered the gold standard (9-12). Hasanzade et al. (13) demonstrated that, for partial-arch impressions, digital impressions were so —or even more— accurate than polyether and polyvinylsiloxane impressions in the fabrication of single-unit, short-span fixed dental prostheses. In addition, digital scans have demonstrated clinically acceptable impressions of one or two contiguous implants (6-8, 10).

As for full-arch impressions, the results of accuracy and trueness are ambiguous. In this regard, Kong et al. (19) demonstrated in a systematic review that the veracity of digital impressions and full-arch irreversible hydrocolloid impressions were similar, and both showed high accuracy. This coincides with Sfondrini et al. (14), who reported that accuracies of digital and alginate impressions were the same. However, Tomita et al. (15) stated that digital impressions showed higher accuracy compared to alginate and polyvinylsiloxane impressions. At the same time, Duvert et al. (16) found that digital impressions were less accurate than polyvinylsiloxane impressions. And Atieh et al. (18) concluded that digital impressions showed lower accuracy compared to polyvinylsiloxane impressions.

On the other hand, full-arch impressions are essential for diagnosis in some dental specialties, such as orthodontics, restorative dentistry, oral rehabilitation, as well as in preoperative evaluation in orthognathic surgery (15-20). Therefore, several *in vitro* studies have concluded that digital impression provides higher accuracy for marginal fit values than the conventional technique, since it avoids possible deformations due to material properties caused by incomplete polymerization. However, one should not exclude the different factors such as saliva, sulcular fluid, blood and patient motion, which could affect the accuracy of the impression in *in vivo* conditions that do not exist in the *in vitro* method (1, 6, 17, 19, 20).

Nowadays, digital impressions, compared to conventional impressions, show excellent accuracy and versatility, and provide a faster workflow, so they are considered acceptable for clinical use. However, consideration should be given to the various causes that may alter the result, such as operator experience, type of scanner, type of software, environment, scanning sequence and oral structures. For these reasons, it is essential to be aware of the factors that can decrease scanning accuracy to maximize precision.

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Photodynamic therapy, a new trend in endodontics for the removal of *Enterococcus faecalis*

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ABSTRACT

Disinfection is achieved through procedures such as instrumentation, irrigation, and intra-canal medication; however, these are not enough since several studies have reported *E. faecalis* as one of the most prevalent persistent microorganisms in root canal treatments that have not achieved healing of the periapical tissues. Efforts have been made to improve disinfection protocols by including different technological tools, as in the case of photodynamic therapy, which uses a light source and photosensitizing substances that favor the process of elimination of the remaining bacteria within the root canal system. The present review of scientific literature delves into the clinical importance of photodynamic therapy and its effect on the disinfection and inhibition of *E. faecalis* within the root canal system, which has become a key element for the success of endodontic treatment.

Keywords: *Enterococcus faecalis*, photodynamic therapy, photosensitizers.

INTRODUCTION

Endodontic treatment is based on the mechanic removal of necrotic pulp tissue and the chemical disinfection of the root canal system (1). Microorganisms and their metabolic by-products are etiological agents of the most frequent endodontic pathologies. Therefore, eliminating or reducing microorganisms within the root canal system should be one of the main objectives for successful treatment (2).

To meet the antimicrobial challenge, solutions are used as irrigants that, during the endodontic procedure, act through continuous contact with target microorganisms. However, these solutions fail to adequately penetrate the dentinal

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tubules, so there is no ideal irrigant solution, as none has all the requirements, including biocompatibility with host tissues, tissue solvent property, antimicrobial effect, and cost (3). On the other hand, penetration of microorganisms into the surrounding dentin occurs through the dentinal tubules, and contamination can reach a depth of approximately 1000 μm. Despite the variety of microorganisms, the dominant species are anaerobes whose microbial load is between 70% and 100% (4).

Enterococcus faecalis is a facultative gram-positive anaerobic microorganism, commonly isolated in primary and secondary endodontic infections. Among pathogenic factors, the most important is the ability to form biofilms, which enhances the resistance of bacteria to antimicrobial agents. Apart from that, the ability to penetrate deep into the dentinal tubules by adhering to the dentinal collagen prevents the antibiotic substances used from making contact (5, 6). Since it is a microorganism frequently found in persistent endodontic infections, the removal of *E. faecalis* from the root canal system is of utmost clinical importance (7).

To obtain better results, efforts have been made to develop novel techniques and devices that boost the disinfection process of the microorganisms present inside the root canal system, such as the use of sonic and ultrasonic tips and, in recent years, light sources inside the canal, as in the case of photodynamic therapy (PDT) (8).

PDT is a disinfection method with a powerful antibacterial action, which is applied against periodontal and endodontic infections and other oral pathologies. This procedure is based on a triad consisting of a non-toxic molecule known as photosensitizer, a light source (lasers, fluorescent lamps or LEDs) and molecular oxygen, where the photosensitizer transfers the energy received to the molecular oxygen and converts it into reactive species, thus causing the death of microorganisms by affecting their membranes, proteins, and nucleic acids.

PDT is mainly used in root canal treatment for root canal disinfection, which is a key procedure in determining its success, thus producing multiple benefits, including high efficiency in reducing bacterial load, reduction of postoperative pain and decrease in the size of periapical lesions. Apart from that, it can increase the efficiency of chemical-mechanical root canal preparation in complex anatomies such as C-shaped canals and in root canal retreatment (9, 10).

The purpose of this review is to investigate, describe and analyze the effectiveness of PDT against *E. faecalis*, as well as its possible impact on the generation of new root canal disinfection protocols.

ENTEROCOCCUS FAECALIS

Bacteria are the main protagonists in the pathogenesis and progression of pulpal and periapical diseases. Therefore, the main objective of a root canal treatment should be to remove microorganisms within the root canal system. *E. faecalis* is the most common strain isolated from teeth with failed root canal treatment and persistent infection (11).

The ability of *E. faecalis* to cause root canal infections has been related to the possession of several characteristics that give it virulence factors. The ability to form biofilms is a dominant characteristic of this bacterium, which extends to resistance to conventional intracanal irrigants (5).

With the advent of proteomic studies, it is revealed that biofilm formation in *E. faecalis* can be managed by a cell-to-cell communication mechanism through signaling molecules called quorum sensing phenomena (5).

The role of the FsrB quorum sensing system as a regulator of pathogenicity, host tissue degradation, and biofilm formation are part of the virulence characteristics of *E. faecalis.* Many characteristics of bacterial biofilms contribute to their increased antimicrobial resistance relative to planktonic cells, including decreased antibiotic penetration, antibiotic sequestration, and the presence of persister cells. Moreover, genetic elements involved in biofilm-associated antimicrobial resistance for *E. faecalis* have been determined. These elements include operon genes encoding two glycosyltransferases (GTF), enterococcal polysaccharide antigen (epa), epaOX and epaI, gelE encoding gelatinase and the fsr quorum sensing system. They also demonstrated that GTFs play additional roles in *E. faecalis*, including cell shape determination, maintaining cell envelope integrity and polysaccharide composition. In addition, an epaOX deletion of *E. faecalis* results in the most notable phenotypic differences in biochemical composition and biofilm architecture (5).

At the same time, it has been shown that wild-type biofilms exhibit a similar architectural arrangement after exposure to daptomycin, a cell membrane-active antibiotic. A connection between biofilm architecture, cell envelope stress and the epa operon is suggested.

Furthermore, with the basic information obtained from FsrB through bioinformatics analysis, it has been shown to be a valid and stable protein with acceptable quality that can be considered as a protein encoded by the target gene for photodynamic disinfection (5).

PHOTODYNAMIC THERAPY

Background

In the 1980s, the foundations of modern phototherapy were laid by Danish scientist Niels Finsen, who worked extensively with light sources ranging from small active rays to ultraviolet radiation. His research enabled other scientists to subsequently use these light sources as a therapeutic modality against Lupus vulgaris and smallpox (12).

In 1990, in a study by German medical student Oscar Raab and Professor Hermann von Tappeiner aimed at finding new drugs against malaria. It was discovered that paramecia incubated with acridine orange (AO) dye died faster right after a thunderstorm. These results were similar to those when AO-treated paramecia were exposed to sunlight from an adjacent window compared to incubation in a darkened room. Therefore, von Tappeiner postulated that light plays a role in the acceleration of the chemical-biological reaction. This phenomenon was called "photodynamics" and its theory was that oxygen was required for the photosensitization process to occur (12).

In 1907, von Tappeiner published a book summarizing the results of his clinical experiments, in collaboration with German dermatologist Albert Jesionek, using the dye xanthene eosin together with illumination to treat basal cell carcinoma, condyloma acuminatum on the female genitalia and lupus vulgaris, with favorable results. This was the first real clinical use of PDT to treat a disease. Subsequently, following the boom in the field of biochemistry and porphyrin compounds, PDT revolutionized. In 1913, the Austrian physician Fredrich Meyer-Betz experimented on himself with an IV injection of 200 mg of hematoporphyrin. Therefore, after exposure to light, he noticed the development of extreme pain and swelling, which was confined to the areas exposed to light. These areas remained photosensitive for several months after the incident. It was thus concluded that hematoporphyrin was a photosensitizing agent and that it also targeted cancer cells more effectively and provided better overall results (12).

In the 1960s, Dougherty et al., following their pioneering studies in both basic science and clinical applications, gained further recognition after conducting clinical trials of PDT on a worldwide scale. They also established the International Photodynamic Association in 1986 and expanded it to several countries around the world. As a result, in 1999, the World Food and Drug Administration approved PDT to treat mainly oncological and dermatological diseases, such as precancerous skin lesions of the face or scalp, cancer and other diseases. It has also been proposed to be useful in almost all specialties of medicine, and potential applications continue to expand every day (12).

In dentistry, PDT is a new disinfection alternative with a powerful antibacterial action, which has a variety of applications, mainly in periodontics and endodontics. In the latter, it is mainly used for root canal disinfection, which is the key point in determining a successful outcome of a root canal treatment. This method has gained popularity in contemporary dentistry due to its various benefits, including high efficiency in reducing bacterial load, reducing postoperative pain and decreasing the size of periapical lesions (10).

Mechanism of action

PDT is a treatment that consists of two stages involving, first, the application and retention of a photosensitizer in the target tissues and, second, activation by exposure to visible light that has an appropriate wavelength and is emitted through a device. This light should be aimed directly at the target. After irradiation, the photosensitizer undergoes a transition from a low energy singlet, ground state, to a higher energy triplet state (9).

There are two mechanisms by which, in the presence of a substrate such as oxygen, sensitizer activation to the triplet state can enter into chemical reactions with biomolecules. Type I mechanisms act through the formation of free radicals by electron or hydrogen transfer. These reactive substances, after interaction with oxygen, can produce highly reactive oxygenated substances, such as peroxide or superoxide anions, which attack target microorganisms. Type I reactions can cause damage to target cell components directly by the action of free radicals (9).

In type II mechanisms, an electronically stimulated and highly oxidizing oxygen state is released, known as singlet oxygen, which would be the main cause of microbial cell destruction. However, it is not easy to distinguish between both PDT reaction mechanisms. A contribution of type I and type II processes indicates

that the mechanism of target cell damage will depend on the oxygen tension as well as the concentration of the photosensitizer (9).

Photosensitizers

Photosensitizers are key elements in PDT, which transfer the energy received to molecular oxygen and convert it into reactive species, causing the death of microorganisms by affecting their membranes, proteins and nucleic acids (10).

Photosensitizers are divided into three subgroups, first, second and third generation. Water-soluble porphyrins called hematoporphyrins are characterized as first-generation photosensitizers. And methylene blue, toluidine blue, photosensitizers®, Foscan®, and 5′-aminolevulinic acid (ALA) are examples of second-generation photosensitizers. The latter have higher singlet oxygen quantum yield, chemical purity and selectivity than first generation photosensitizers. Third-generation drugs have recently been investigated with the main objective of reducing damage to healthy cells and increasing bioavailability. These substances generally consist of drug delivery systems, genetically engineered technologies or combinations of monoclonal antibody receptors (13).

There are natural photosensitizers. There are many natural compounds extracted from plants and other organisms that act as photosensitizers and absorb white or UV-A light. There are still many natural photosensitizer compounds to be discovered, so variety cannot be restricted. However, so far, they include coumarins, furanocoumarins, benzofurans, anthraquinones and flavin derivatives. Hypericin and curcumin are two natural compounds that have been extensively studied (14).

An ideal photosensitizer should:

- Have strong absorption in the peak of the red to near-infrared spectral region (between 650 nm and 800 nm).
- Possess substantial triplet quantum yield leading to a good yield of reactive oxygen species after irradiation.
- Have high tissue selectivity.
- Not exhibit obscure toxicity.
- Have ideal solubility to maintain lipophilic ability to cross the phospholipid membrane and avoid self-aggregation.
- Exhibit high stability under storage conditions.
- Kill microorganisms sufficiently without damaging eukaryotic host cells.
- Show optimal absorption, distribution, metabolism, and excretion (ADME).
- Have a small size to allow penetration of the microbial membrane.
- Have low manufacturing costs (13).

Light sources

Light sources used for root canal PDT include helium-neon and argon lasers, neon lasers, metal vapor lasers, and diode lasers. Due to the disadvantages of high-power lasers, such as tooth surface change and thermal damage to periodontal tissues, as well as the lack of antimicrobial activity, low-level lasers are used for the activation of photosensitizing molecules. The application of low-level lasers in endodontics, such as diode lasers, improves periapical tissue healing and reduces post-treatment discomfort and complications (15).

Nowadays, among low-level lasers, the diode laser is preferred due to its low cost and portability. The light emitting diode (LED) has been one of the most favorable disinfection methods recently. It emits narrow-spectrum uncollimated light across the ultraviolet to near-infrared wavelength ranges. Advantages such as low cost, ease of use and lower power consumption compared to laser made it a desirable alternative device. In addition, it is portable, flexible, lightweight and, most importantly, it does not increase tissue temperature, thus avoiding additional tissue damage. LED has been applied in many clinical fields, such as pain relief, skin rejuvenation, wound healing and viral diseases. Recently, it was suggested that LEDs can be used instead of diode lasers as the light source for PDT (15).

Protocol of use

The root canal is filled with 0.5 mL of photosensitizer, with a pre-irradiation period of 5 min. Subsequently, the diode laser fiber is inserted into the root canal with a wavelength of 635 nm, an output power of 220 mW and a power density of 3.05 W/cm^2 or LED fiber with a wavelength of 635 nm and a power density of 2000-4000 mW/cm^2, emitting light in continuous wavelength (CW). Irradiation is performed for 30-90 seconds. Fiber moves into the root canal in apico-cervical helical movements. Finally, the root canal is irrigated once again with 5 mL of sterile saline to remove the photosensitizer (16). When natural photosensitizers are used, the synergistic

use of irrigants, such as ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl), is recommended (6, 17).

DISCUSSION

PDT is a disinfection method that has demonstrated antimicrobial capacity against *E. faecalis*, which has become clinically relevant as a persistent organism in primary and secondary infections of root canals (7).

To improve the antimicrobial effectiveness of PDT, the use of photosensitizers is recommended. Afkhami et al. (15) compared the use of photosensitizing substances, such as methylene blue and toluidine blue, demonstrating greater efficacy of the latter due to its amphiphilic characteristics, which generate the elimination of bacteria present in the root canal, which is also due to its high binding capacity to *E. Faecalis*.

Mozayeni et al. (17) compared the efficacy of toluidine blue, methylene blue and a natural compound, such as curcumin, in PDT against *E. Faecalis*, all these compounds used synergistically with NaOCl; and it was concluded that the use of toluidine blue with NaOCl and curcumin with NaOCl are superior when eliminating *E. Faecalis* versus the methylene blue group with NaOCl. Cusicanqui et al. (6) also evaluated curcumin as a photosensitizer, and obtained statistically favorable results when it was combined with EDTA or hydroxyethylidene bisphosphonate (HEBP) against an *E. faecalis* biofilm, as chelators appeared to contribute to the reduction of the vitality of the inner layers of the biofilm.

On the use of other natural compounds, Pourhajibagher et al. (11) demonstrated that the use of Chlorella in PDT against *E. faecalis* was very effective. This reinforces the use of natural photosensitizers that could avoid adverse reactions from any synthetic or mineral compound.

Regarding the effectiveness of the different light sources, currently the most used are LED light and diode laser. Afkhami et al. (15) demonstrated that there is no significant difference between them; however, the use of photosensitizers is necessary to increase their antibacterial capacity.

On the other hand, it is important to mention that PDT is mainly used as a complement to irrigation protocols and in the last disinfection phase of endodontic treatment. De Vasconcelos Neves et al. (16) compared PDT with diode laser and methylene blue, NaOCl plus PDT, PUI with NaOCl plus PDT and XP Endo Finisher with NaOCl plus PDT, and noticed that XP Endo Finisher plus PDT protocol resulted in the highest percentage of inhibition (100%), probably due to the ability to generate infiltration of the irrigant and photosensitizer in areas of difficult access within the root canal system compared to PUI and conventional irrigation. Therefore, developing new final disinfection protocols will benefit the elimination of pathogenic microorganisms within the root canal, generating higher treatment success rates (16).

Mustafa et al. (1) demonstrated in an *in vitro* study that PDT was superior in the removal of *E. faecalis* in C-canals versus hand instrumentation alone due to its ability to enter the complex anatomy of these canals. On the other hand, Maciel Martins et al. (2) demonstrated that, when saline plus PDT and EDTA plus PDT were used, superior results were obtained in the elimination of *E. faecalis*, being 97.6% and 89.8%, respectively, compared to only using saline (68.2%) and only EDTA (76.4%). The same conclusion was obtained by Sarda et al. (3), who demonstrated the superiority of PDT plus NaOCl in the 98% elimination of *E. faecalis*, compared to PDT alone (73%) or 3% sodium hypochlorite alone (76%).

CONCLUSIONS

This literature review on the effectiveness of PDT against E. faecalis concludes that PDT increases the disinfection and inhibition effect when the traditional disinfection protocol is carried out in an adjuvant manner. The use of photosensitizers increases the effectiveness of PDT, with toluidine blue obtaining the best results. On the other hand, in relation to the light source used, such as LED and diode laser, there are no significant differences. The disinfection protocol proposed by De Vasconcelos Neves et. al (16), which used XP Endo Finisher followed by PDT, resulted in the percentage of 100% inhibition *in vitro*. Therefore, complementary clinical studies should be performed in that sense. It is advisable for future PDT research to conduct clinical studies with long-term controls to revalidate the results obtained today.

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CASE REPORT

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Spontaneous re-eruption of a primary tooth with intrusive luxation-type trauma: follow-up of a case

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RASC: data curation, investigation, resources, validation, visualization, writing – original draft.
RLRC: data curation, investigation, validation, visualization, writing – original draft.
EPVG: data curation, investigation, methodology, project administration.
GAPMP: conceptualization, data curation, investigation, methodology, project administration, supervision, validation, visualization, writing – original draft, writing – review & editing.

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ABSTRACT

Trauma in the primary dentition often requires different management than in the permanent dentition. We present the case of an 18-month-old female patient, in apparent good general condition, with no medical history, who came to the pediatric dentistry service of the Teaching Dental Center of the Universidad Peruana Cayetano Heredia because "a tooth had become embedded when she fell". After the extraoral examination, edema was observed in the lower lip and intraorally there was an apical displacement of tooth 61. Radiographically, it is observed that tooth 61 is rotated with apical displacement. Diagnosis: Intrusive dislocation of tooth 61 and contusion of the lower lip. Treatment: Washing with physiological saline solution, soft diet, and use of a soft bristle toothbrush; she was kept under observation. Controls: Follow- up was carried out for seven months, during which time spontaneous re-eruption of the affected tooth was observed. Therefore, spontaneous re-eruption is a treatment option in intruded primary teeth after trauma.

Keywords: dental intrusion, dental trauma, child.

INTRODUCTION

Dentoalveolar trauma treatments frequently occur in preschool age at an average of 22.7% in the world population (1). They are more prone in the first years of life because infants do not have much stability as they are learning to walk (2). Intrusion occurs when the tooth moves apically into the alveolar bone. Clinically, axial displacement is observed within the alveolus of the affected tooth and this one is immobile (3).

In this context, an important point is to know the sequelae that this injury can cause in the permanent dentition. Evidence mentions that there is a high probability of a defect in the development of the enamel of the permanent tooth affected by the intrusion (4), as well as root canal obliteration and pulp necrosis of the primary tooth (5).

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Against this backdrop, the question that always arises is: In what cases should we intervene or wait when this type of accident occurs? According to the 2020 International Association of Dental Traumatology (IADT) Guidelines, the only suggested treatment is to allow re-eruption without intervention (spontaneous repositioning) (6).

The objective of this case report is to determine the diagnosis and proper management of intrusive luxation in primary dentition.

CASE PRESENTATION

18-month-old female pediatric patient in apparent good general condition, with no medical history of importance. She and her mother went to the Pediatric Dentistry Service of the Teaching Dental Center of Universidad Peruana Cayetano Heredia on October 12, 2022. The mother said that her youngest daughter "had a tooth embedded when she fell". The event occurred while the little girl was walking without the supervision of her caregiver, thus impacting against the bed platform. Due to her age, the patient was not very receptive, so, with the mother's consent, the extraoral and intraoral examination was performed under active protective stabilization.

On the extraoral examination, edema was observed at the level of the lower lip; and on the intraoral examination, it was warned that tooth 61 was displaced apically and that there was an absence of mobility of the adjacent teeth (Figure 1).

Figure 1. Extraoral evaluation: edema of the left lower lip area is observed. Intraoral evaluation: apical displacement of tooth 61 is observed.

To complement the diagnosis, periapical radiography of the area was indicated, where gyroversion of tooth 61 with apical displacement was observed (Figure 2). The definitive diagnosis was intrusive dislocation of piece 61 and contusion of the lower lip.

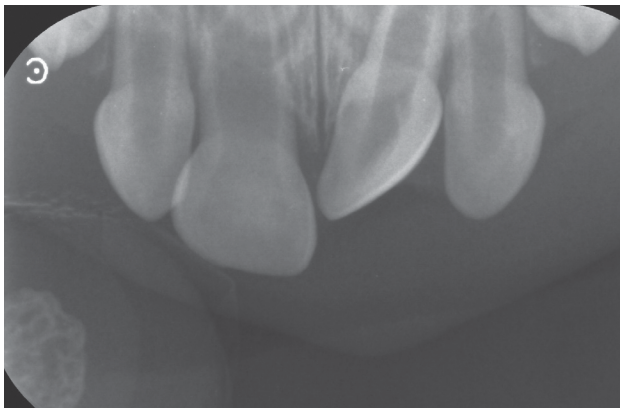

Figure 2. Periapical radiography: tooth 61 rotated with apical displacement.

The treatment followed the recommendations of the International Association of Dental Traumatology (IADT), which consist in observing and monitoring the affected tooth, allowing its spontaneous reposition, regardless of the displacement direction. The affected area was washed with physiological saline solution and the traumatized tooth was kept under observation. Analgesic medication was administered according to the patient's age and pain condition. Instructions were given to the mother, which included a soft diet and cleaning with a soft bristle brush.

The first checkup was 2 months after the trauma. The patient was asymptomatic with clinical and radiographic evidence of partial re-eruption of tooth 61, with the presence of gyroversion (Figure 3). 5 months after the trauma, the patient was asymptomatic. Clinical examination showed no fistula and no change in the color of tooth 61 (Figure 4). After 7 months, the patient was asymptomatic, and complete re-eruption of tooth 61 was clinically observed with mesial gyroversion, slight color change and absence of fistula.

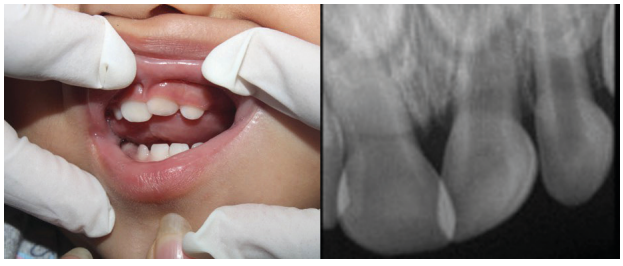

Figure 3. Checkup after 2 months of the trauma. Clinically, partial re-eruption of tooth 61 is observed. Radiographically, it shows an open apex of the compromised tooth.

Figure 4. Checkup after 5 months of the trauma. Clinically, hard and soft tissues with normal characteristics are observed.

Radiographically, complete root formation of tooth 61 with its gyroversion is observed (Figure 5). Finally, we will give an additional follow-up at 6 years of age to control the eruption of the permanent tooth, as well as a radiological checkup only in case of clinical findings that suggest pathology. Apart from that, we will inform parents to pay attention to any symptomatology or clinical change of the tooth (e.g. change in color, presence of pain, sinus tract, increased mobility, etc.). If this occurs, they should return to the hospital as soon as possible.

Figure 5. Checkup after 7 months of the trauma. Clinically, healthy hard and soft tissues are observed around tooth 61. Radiographically, complete root formation of the traumatized tooth is shown.

DISCUSSION

Dentoalveolar trauma in preschool children ranges from 6.2% to 41.6%. According to a recent systematic review by Patnana et al. (7), this prevalence is currently 24.2%.

Primary teeth are highly prone to luxation (displacement) injuries that constitute 21-81% of all dentoalveolar trauma (5). This is probably due to the spongy nature of the alveolar bone, the large proportion of tooth length within the bone, shorter crowns and cuneiform shape that favors intrusion.

Goswami et al. (5), in a systematic review, find that the most common age group of children affected by dislocation injuries is 0 to 3 years, as described in one of the studies included in that review. On the other hand, three other studies, also reviewed by the cited authors, described the increased incidence of intrusive dislocation among the age range of 1 to 4 years, as presented in our case, with 18 months of age.

According to the literature, dental intrusions can be divided into three grades, determined according to the percentage of visualization of the clinical crown that remains in the arch: in grade I it is possible to observe more than 50% of the clinical crown; in grade II less than 50% is observed; and in grade III, as in our case, 100% of the crown is intruded (8). As different authors mentioned, treatment options for this type of luxation in the primary dentition were previously divided according to the degree of intrusion. Therefore, for grade I or mild and grade II or moderate, spontaneous re-eruption was expected. In the case of intrusion III or severe, exodontia was suggested, a measure supported until 2019 according to IADT guidelines (9).

However, according to the new IADT guidelines, extraction is no longer recommended for the following reasons: 1) evidence of spontaneous re-eruption of intruded primary teeth; 2) concern that further damage to the tooth germ may be inflicted during extraction; and 3) lack of evidence that immediate extraction minimizes further damage to the permanent tooth germ (6). In addition, immediate extraction of the intruded tooth at this age may cause significant occlusal asymmetries, as well as phonetic and swallowing complications (tongue thrusting), which can only be treated by the placement of removable appliances such as space maintainers (10). Therefore, conservative treatment consists in waiting and monitoring spontaneous re-eruption, regardless of the degree of intrusion of the tooth.

A report by Mérida et al. (9), with a conservative monitoring treatment in a 22-month-old patient, was successful after 13 months of follow-up, showing a complete re-eruption, located in the occlusion plane without symptoms and significant changes. However, in the last radiographic control there was an irregularity in the middle third of the root, compatible with possible root resorption and widening of the

periodontal ligament space. For this reason, regular clinical and radiographic checkups are important up to the time of tooth replacement. Defabianis et al. (2) mention that the age of the child at the time of tooth eruption is related to the degree of intrusion. Spontaneous eruption can occur within 5 months after trauma for partially intruded teeth, regardless of the age of the child, and for fully intruded teeth in children under 2 years of age. In older children, complete dental re-eruption should be expected at an interval of 5 to 11 months (2). In our case, partial re-eruption of the compromised specimen was observed at 2 months after follow-up and complete re-eruption at 7 months after follow-up.

CONCLUSIONS

Dental trauma is a fortuitous event, with potentially important permanent consequences. Therefore, decision making based on the best available scientific evidence will be decisive for the choice of the best treatment. Spontaneous re-eruption is a successful treatment option in intruded primary teeth in the absence of damage to the permanent tooth. Having a high prevalence and a high potential for alteration to developing germs, it is necessary to raise awareness of the true management of this type of traumatic injury. As we reported in this case, continuous follow-up planning up to the moment of tooth replacement is important, and we should inform parents of the possible sequelae in permanent teeth.

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CASE REPORT

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RRS: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review & editing.
ORP: conceptualization, data curation, investigation, methodology, resources, validation, writing – original draft, writing – review & editing.
YRMP: conceptualization, data curation, formal analysis, investigation, software, validation, visualization, writing – review & editing.

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Orofacial clinical-radiological features of McCune-Albright syndrome in an adult: a case report

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ABSTRACT

Fibrous dysplasia is a benign and progressive bone disease of genetic basis that can affect one or several bones. Its high incidence in the pediatric age served as a basis for it to be previously considered exclusive to this stage; however, there are reports to date that show its development and later growth in the second decade of life. When associated with endocrine imbalances and café-au-lait spots, it is part of the McCune- Albright syndrome. The present case report shows the clinical and radiologic features of the oral-facial region of an adult patient with McCune-Albright syndrome. Lesions in the jaws affect the morphology and cause dysfunction. At the dental level, the changes produced result in malocclusion and structural defects. Radiological studies showed changes with mixed density and ground glass pattern.

Keywords: McCune-Albright syndrome, fibrous dysplasia, café-au-lait spots.

INTRODUCTION

Fibrous dysplasia is a benign fibro-osseous lesion of bone first described by Lichtenstein in 1938 (1). It is a pathology of very low prevalence, so its diagnosis goes unnoticed in most cases (2). It is of genetic basis and slow progression, characterized by the progressive replacement of normal bone by fibrotic tissue. The process can affect a single bone (monostotic fibrous dysplasia) or multiple bones (polyostotic fibrous dysplasia) (3). The most common location of fibrous dysplasia is in the membranous bones, such as the femur, tibia, and pelvic bone. The skull is also a frequent site of involvement (4).

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Traditionally, it has been considered a disease of childhood, inactive after puberty; however, the emerging concept now seems to be that fibrous dysplasia can progress into adulthood (5).

When fibrous dysplasia is associated with endocrinopathies or hyperpigmented skin lesions, it corresponds to the McCune-Albright syndrome (2). The aim of this study is to describe clinical and radiological oral-facial features of the McCune-Albright syndrome in an adult patient in order to report the increased bone growth in this stage of life and thus support the current concepts that dismiss fibrous dysplasia as an exclusive childhood disease.

CASE PRESENTATION

A 32-year-old female patient from a rural area came to the maxillofacial surgery department concerned about a facial growth in the last five years. During the interrogation, she reported that in her childhood she began to have a discrete increase in volume in this area, so she had a checkup in the pediatric services of her province of origin. In the clinical record presented by the patient, a diagnosis of McCune-Albright syndrome was registered in 2005, and it was issued by a multidisciplinary consultation and supported by a histological result of fibrous dysplasia, history of menarche at the age of 8 and café-au-lait spots in the affected region. Due to unspecified reasons, the patient did not attend her medical checkups and argued that the greatest growth occurred in the last five years.

After the oral physical examination, facial asymmetry was observed, marked by an increase in volume of hard consistency in the right region, slight pupillary unevenness, deviation of the labial commissure towards the lower contralateral side. There were no dermatological alterations (Figure 1). Oral examination showed midline deviation to the left side during the opening movement and slight limitation to the right laterality with respect to the left. Increased gingival stippling was observed in the gingiva of the right mandibular hemiarch, as well as increased protrusion and anterior overjet. Clinical, laboratory and imaging studies were conducted, as well as consultations with other specialties, including internists, endocrinologists, radiologists, psychologists, general stomatologists, orthodontists, and periodontists.

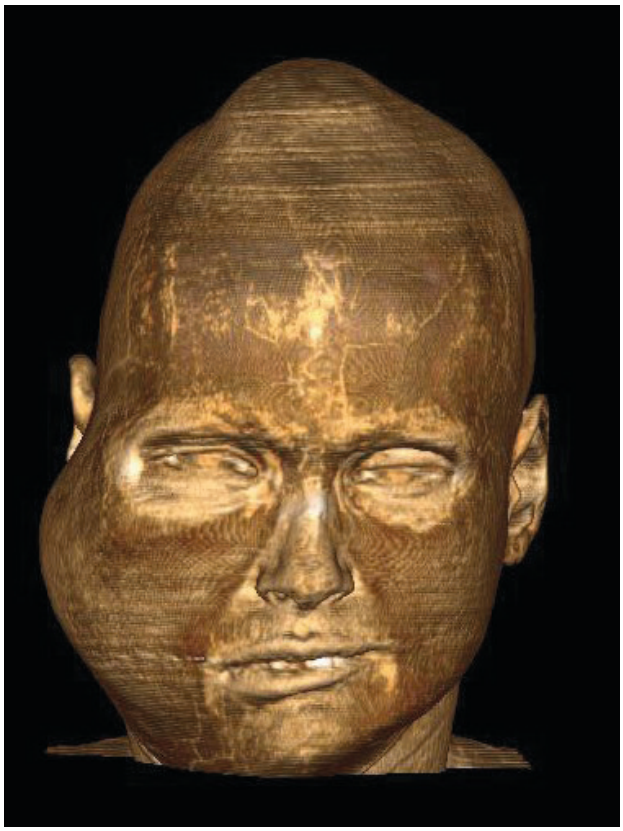

Figure 1. Volumetric reconstruction with soft tissue view showing facial asymmetry due to volume increase in the right facial region. No photograph is exposed by patient's decision in the consent form.

Panoramic radiography showed heterogeneous radiopacity in the right mandibular body and ramus region with predominant lytic areas in the angle and marked sclerotic lesions in the condyle. The roots of the lower molars were separated. At the same time, apical to them, the bone adopted the typical ground glass pattern. The lower right third molar was absent; in a superior position and distal to the apex of the second molar, it presented a radiopaque image with unclear morphological features similar to an odontoma. The left third molars did not present morphological anomalies (Figure 2).

Axial and coronal views on tomography showed lesions with thinning of the cortex, abnormal bone pattern, and loss of trabecular architecture. No alterations were found in the maxillary sinus, ethmoidal cells or orbital cavity (Figure 3).

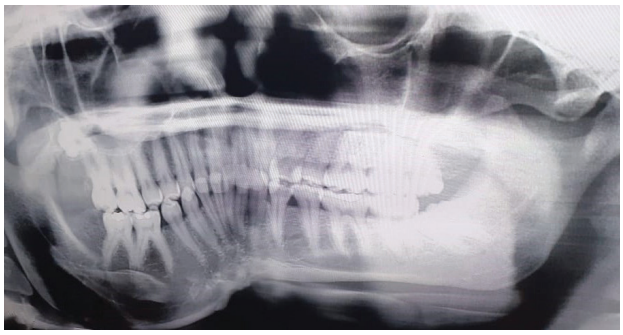

Figure 2. Panoramic radiograph showing mixed radiopacity in body and left mandibular ramus with presence of lytic areas, sclerotic and ground glass pattern in the dentate region. Radiopaque area with odontoma aspect in the region of 18 and absence of 48.

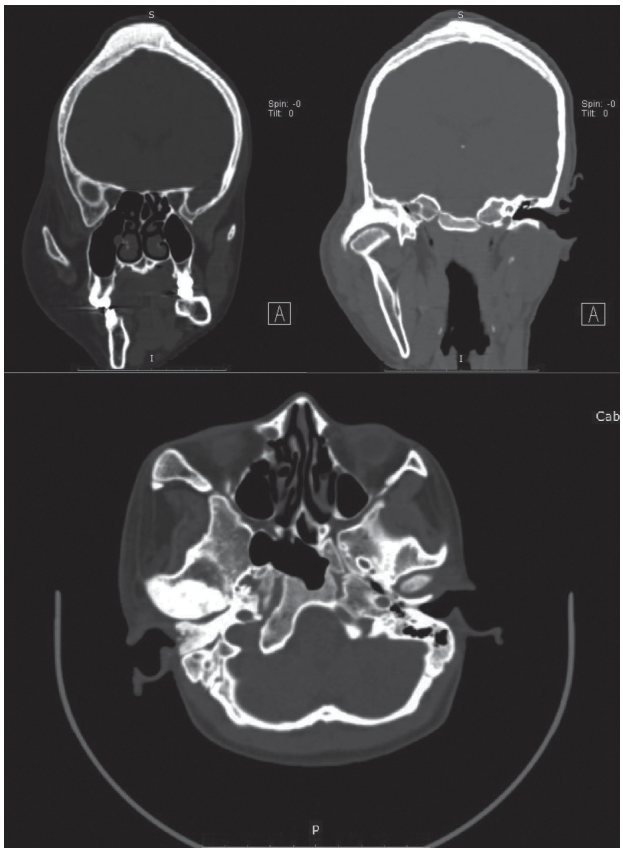

Figure 3. Axial and coronal reconstructions showing bone lesions and preservation of the maxillary and ethmoidal sinuses and the orbital cavity.

Volumetric reconstruction showed an expansive growth involving the right side of the mandible and the zygomatic bone, as well as a protrusion at the cranial upper pole. A height difference was observed between both infraorbital rims. The right mental foramen was inferior to the left one (Figure 4).

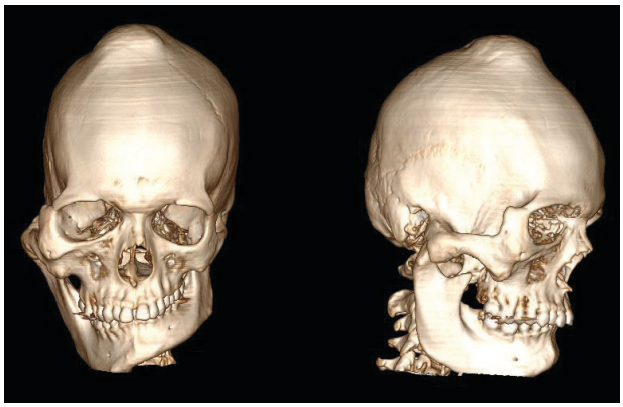

Figure 4. Volumetric reconstruction (frontal and lateral). There is an expansive growth affecting the right mandibular side and the zygomatic bone, as well as a protrusion in the upper pole of the skull.

Laboratory and other additional tests were found in normal parameters. There were no functional alterations, except for a slight restriction of lateral mandibular movement. By decision of the patient, an expectant therapeutic approach was applied.

DISCUSSION

Benign fibro-osseous lesions rarely affect the sinonasal tract and are divided into three different entities: osteoma, fibrous dysplasia and fibroma ossificans (6, 7). Fibrous dysplasia is a rare skeletal disease caused by activating mutations of the GNAS1 gene (8-10). It is known to frequently affect craniofacial bones, including the maxilla and mandible. However, its effects on dental tissues and implications for dental care are still unclear (11).

In the 1930s, McCune and, a year later, Albright presented patients with certain characteristics: fibrous dysplasia of one or more bones, café-au-lait spots on the body and precocious puberty. These patients were later identified as carriers of the syndrome that bears the surnames of these physicians: McCune-Albright syndrome (12). This disease is a rare, non-inherited condition. Although prevalence data are not available, it has been reported to occur in ranges from 1/100 000 to 1/1 000 000 000 (8, 12).

Café-au-lait macules are an isolated and common dermatologic finding in the general population (13) and are due to an active proliferation of melanocytes and consequent hyperproduction of melanin (14). In a study by Akintoye et al (8), it was pointed out that 63% of patients with this syndrome had multiple dysregulated endocrine/metabolic functions. The

most common were hyperthyroidism, precocious puberty and renal phosphate wasting.

Gnatic fibrous dysplasia usually appears in the second or third decade, which may be due to initial misdiagnosis or lack of symptoms. More than 90% of lesions are monostotic and affect only one bone, which is true only for the mandible in the craniofacial region because fibrous dysplasia lesions in the maxilla can cross sutures to the sphenoid, zygoma, skull base and frontonasal bones, thus affecting more than one bone (1, 9).

In fibrous dysplasia, the bone grows in the form of a painless swelling, while the maxilla and mandible are most often affected in the head and neck area, and the ethmoid bone is rarely affected. Once the definitive diagnosis has been made through histopathological studies of fibrous dysplasia, consultation is necessary to rule out an endocrine disorder (15). General imaging studies can rule out extracranial extension of fibrous dysplasia (plain radiographs, CT scans or bone scans). Clinically, lesions can be classified as inactive (stable), non-aggressive (slow growth) or aggressive (rapid growth ± pain, pathological fractures, malignant transformations, etc.) (1).

Maxillary lesions affect both orbital morphology and content and dental occlusion. At the mandibular level, it presents with a mass at the lower border of the mandible, and later the progression of the disease will lead to dysfunction (16). Oligodontia, enamel hypoplasia, enamel hypomineralization, as well as tooth wear, rotation and displacement are examples of dental anomalies in fibrous dysplasia. The infraorbital nerve and the inferior alveolar nerve may be involved in the lesion (1).

The progression of fibrous dysplasia often decreases as patients reach puberty; however, cases with ongoing active disease have been reported (1, 5). In adulthood it can be reactivated, for example, during pregnancy (1).

Akintoye et al. (8) observed four types of radiological changes in fibrous dysplasia: ground glass (granular/condensed trabeculae), radiolucent (lytic), mixed radiolucent/radiopaque (mixed density), and radiopaque (sclerotic). The characteristic "ground glass" appearance is the result of interwoven or abnormal bone superimposed on a matrix of fibrous tissue (17). It has been observed that older subjects and patients treated with bisphosphonates have radiologically sclerotic lesions (8, 17).

Computed tomography is excellent for assessing the volume and morphology of tumors and can be helpful in determining the degree of bone involution. Magnetic resonance imaging offers a more preponderant specificity in neurovascular and ocular involution (5). A ground-glass appearance on CT scans, thinning of the cortical bone and bulging of the affected area are the distinctive and special features of fibrous dysplasia (5, 8). The indications for surgical procedures include functional and esthetic alterations of the affected area (8). In the present case, despite having marked facial asymmetry, the patient advocated a wait-and-see approach.

CONCLUSIONS

In this case report, the clinical-radiological characteristics of an adult patient with fibrous dysplasia could be appreciated, where the greatest dysplastic changes occurred after 25 years of age. The diagnosis was supplemented at the age of 15 years as McCune-Albright syndrome because it was associated with endocrine imbalances and café-au-lait spots. Deforming lesions were observed in the bones of the facial mass with marked asymmetry. Structural dental alterations and malocclusion determined the fundamental oral features. Radiological studies showed the typical ground-glass pattern and mixed density changes. A multidisciplinary approach and the use of appropriate diagnostic aids are important to establish the involvement of this disease.

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CASE REPORT

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Diagnostic utility of CD117 in an unusual adenoid cystic carcinoma of the upper lip

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Authorship contribution:
RG, RA and JAS: conceptualization, data curation, formal analysis, investigation, methodology, project administration, visualization, writing – original draft, writing – review & editing.
CC and KA: data curation, investigation, methodology, visualization, writing – original draft, writing – review & editing.

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ABSTRACT

Adenoid cystic carcinoma (ACC) is a malignant neoplasm of the salivary gland, of slow evolution but aggressive behavior, which frequently occurs in the palate; however, in the upper lip, where more benign neoplasms are usually found, its presence is scarcely reported. We report the case of a 63-year- old woman, referred for presenting a nodule in the right upper lip, with benign appearance, firm consistency, circumscribed, mobile, painful to palpation, with no determined time of evolution and whose histopathological study showed a proliferation of angular and hyperchromatic cells with scarce cytoplasm, organized in a cribriform pattern and predominantly tubular. An immunohistochemical study was performed, which showed positivity for SMA, p63 and CD117 with a Ki-67 of approximately 10%. These results confirm the diagnosis of ACC with tubular pattern, highlighting the role of CD117 for the differential diagnosis with polymorphous adenocarcinoma. The patient was referred for surgical treatment and radiotherapy, and after one year of follow-up she maintained a good clinical behavior.

Keywords: adenoid cystic carcinoma, CD117, salivary gland neoplasm.

INTRODUCTION

With a reported annual incidence of 3 to 4.5 cases per million population, adenoid cystic carcinoma (ACC) is a rare malignant salivary gland neoplasm that accounts for approximately 1% of all malignant head and neck tumors and about 10% of all salivary gland neoplasms (1). This tumor is frequently located in the minor salivary glands (45-68% of cases), especially in the palate (66%), while it is less frequently observed in the upper lip (5-20%) (2).

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Clinically, ACC presents with ulceration and pain, although with slow growing, where almost half of the affected patients develop distant metastases within the first 5 years from diagnosis, while local recurrences tend to develop even later, even after 8 years post-treatment (1, 2), a characteristic that reveals its aggressive behavior and its description as a high-grade malignant tumor (3). Histopathologically, three histological patterns are described in ACC: cribriform, tubular and solid, which can occur simultaneously in the same tumor. Therefore, it is relevant to determine the predominant pattern for its subsequent grading (3, 4).

We report a clinical case of a patient with ACC located in the upper lip, something extremely uncommon and with special emphasis on the clinical presentation, which at the time of surgery suggested the diagnosis of a benign neoplasm. Moreover, the importance of the use of the immunomarker c-kit or CD117 in the confirmation of the diagnosis is described, which allows to rule out frequent differential diagnoses of this pathology.

CASE PRESENTATION

We present the case of a 63-year-old woman with controlled hypothyroidism, referred to the Maxillofacial Dental Service of Hospital de Los Andes, Chile, due to a nodular enlargement of firm consistency, circumscribed, mobile, painful to palpation, located in the thickness of the upper labial mucosa on the right side, of apparent long standing and slow growth, located in the thickness of the labial mucosa on the right side (Figure 1A). At the time of biopsy, a yellowish lesion was observed, lobulated in its deepest portion, and apparently adherent to adjacent planes (Figures 1B and 1C).

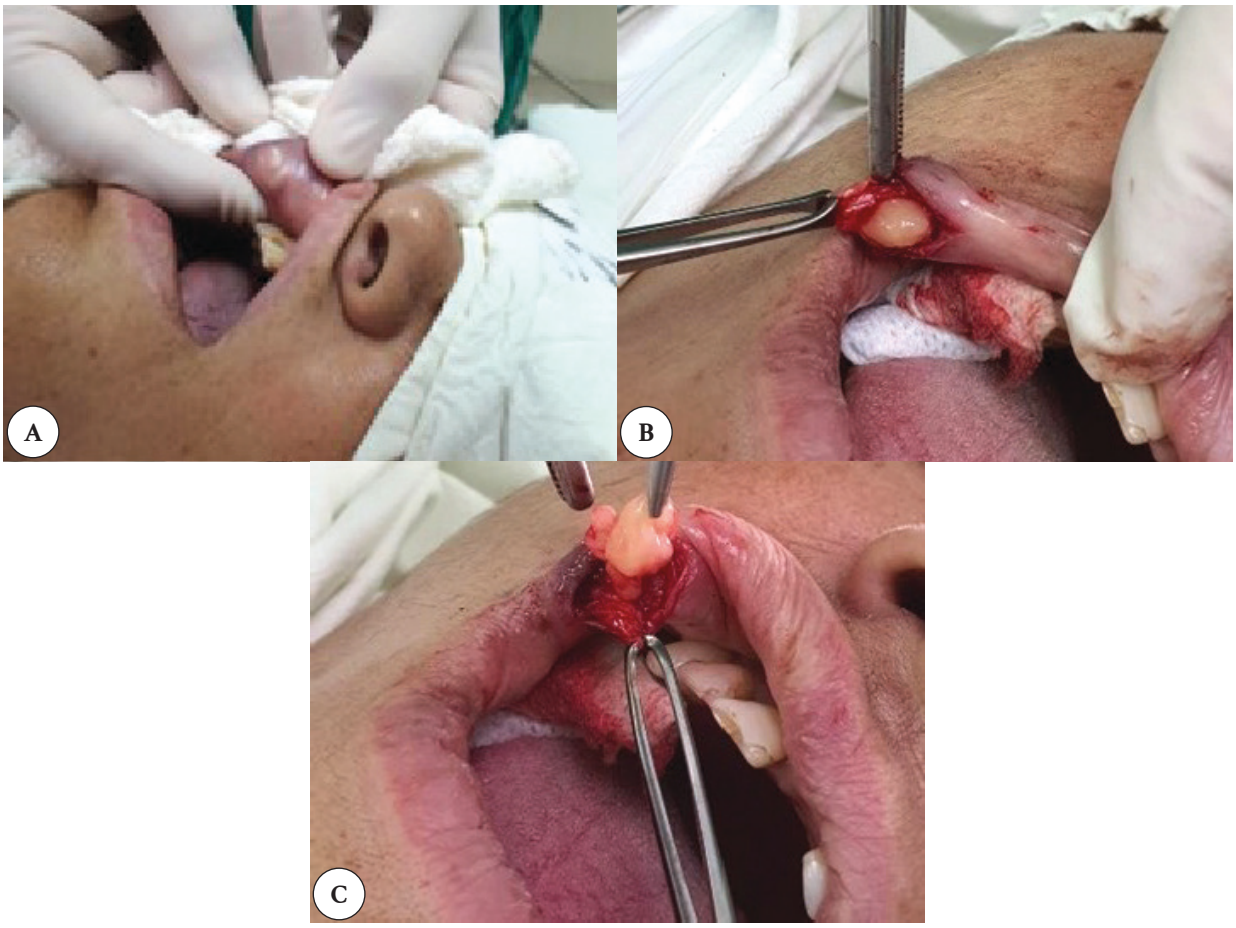

Figure 1. Clinical and surgical aspect of the lesion.
A: Appearance of the lesion before surgery.
B and C: Image of the excisional biopsy of the lesion.

A microscopic analysis performed at the Anatomic Pathology Unit of Hospital San Camilo revealed a partially delimited tumor, in which a proliferation of hyperchromatic and angulated cells with scant cytoplasm stands out, forming multiple microcystic spaces with eosinophilic content of mucinous appearance, organized in a cribriform and predominantly tubular pattern with focal areas of solid islands (Figures 2A and 2B). The stroma is fibrous with few inflammatory cells. No vascular or perineural infiltration is observed. No atypical mitoses or areas of necrosis are identified. Neoplastic proliferation affected all surgical margins. Immunohistochemical staining for CD117, also known as c-kit, was conducted, showing positive cytoplasmic labeling, mainly in the inner cells (Figure 2E). Positive marking is also observed in abluminal cells for p-63 (nuclear) and SMA (cytoplasmic) with increased intensity (Figures 2C and 2D). GFAP immunohistochemical staining was negative and Ki-67 (or cell proliferation index) showed positivity for about 10% of the sample (Figure 2F).

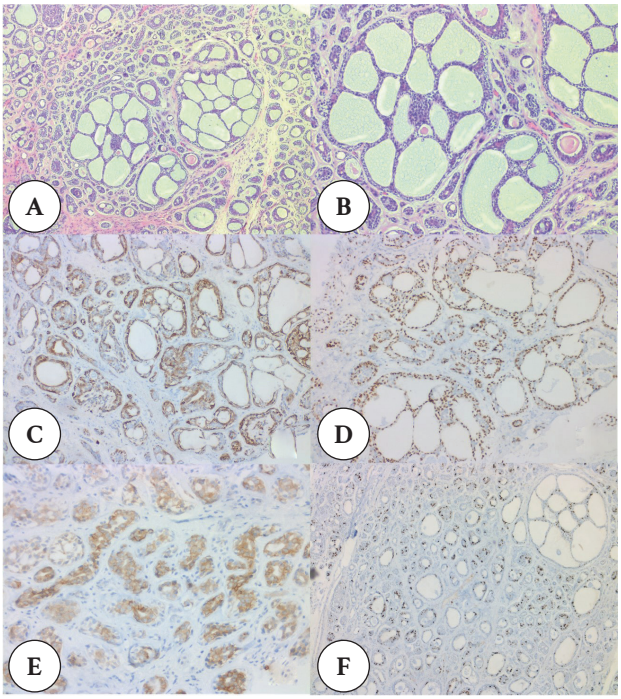

Figure 2. Histopathologic features of the neoplasm. A: Proliferation of tumor cells in a cribriform and tubular pattern. B: Cribriform islands formed by cells of scarce cytoplasm and hyperchromatic nucleus with microcysts of mucinous content. C: Cytoplasmic myoepithelial cells positive for SMA. D: Nuclear positive myoepithelial cells for p63. E: Internal cytoplasmic CD117-positive cells. F: Ki-67 with a rate of 10%.

Finally, a malignant epithelial proliferation compatible with tubular-predominant ACC was diagnosed. The patient was referred to hospital treatment and underwent further surgical treatment, combined with postoperative radiotherapy, showing so far, a good clinical behavior.

DISCUSSION

The value of the present case lies in the importance of establishing differential diagnoses, especially due to its apparent benign clinical appearance, which could suggest diagnoses such as lipoma (5) or some salivary gland neoplasm more frequent in that location, such as pleomorphic adenoma (PA) and canalicular adenoma (CA), whose most common location (in the case of CA) is precisely the upper lip (6). With respect to ACC, approximately only 5% of cases would present in the upper lip (7), while, within malignant tumors affecting the upper lip, ACC accounts for 1.7% of cases (8).

Although histologic appearance is highly suggestive of an ACC, the complement of an appropriate immunohistochemical analysis is relevant, especially to establish prognosis and differentiate from other salivary gland neoplastic entities. It has been reported that immunostaining with CD117 can be useful to differentiate two neoplastic entities, such as ACC and polymorphous adenocarcinoma (PCA), in which their cribriform and tubular patterns can be confused. CD117 shows strong diffuse cytoplasmic reactivity in more than 80% of ACC tumor cells, whereas less than 20% of cells show negative to weak positivity in PCA (8). In our report, the positive immunolabeling for this protein was approximately 90%, which coincides with that described by Mino et al. (9), who observed positive labeling in 89% of tumor cells. Other immunohistochemical stains useful in the diagnosis of ACC include p40 and GFAP, especially when their analysis is combined with p63 immunolabeling (10). In the case presented, immunolabeling was performed for p63, which was positive, while there was no immunolabeling for GFAP, which coincides with what is described in the literature. In this sense, positivity for p63 in abluminal cells and negativity for GFAP are useful to differentiate ACC, especially from PA; and in the case of positive CD117 immunolabeling, this will allow differentiating ACC from PCA (9, 10).

In the upper lip, ACC appeared as a slow-growing nodule that commonly does not appear with significant early symptoms. This not only coincides with what has

been described in the literature, but also reinforces the need for early diagnosis. Due to its slow evolution and apparently benign behavior, the patient's diagnosis is usually delayed (11, 12).

Regarding prognosis, histologic features have been correlated with prognosis with inconsistent results (13). It has been suggested that the solid pattern appears to be more aggressive and may be associated with an adverse clinical course and poor prognosis (14). On the other hand, other studies have not identified any correlation between histological subtype and clinical behavior (15).

Infiltrative growth and perineural invasion present in ACC are other features associated with prognosis, considered as the worst prognosis when they are present (16). This would explain the high risk of recurrence of this neoplasm, which could be interpreted as an incomplete surgical excision or invasion of structures that favor metastatic processes. However, other authors have not identified any correlation between perineural invasion and prognosis (14), which marks a controversy regarding the prognosis of this pathology. In turn, a positive microscopic surgical margin is associated with a worse prognosis (17). Currently, surgical resection of the tumor in combination with adjuvant radiotherapy is practically the most effective method of choice (1, 18), treatment that coincides with what was done in the present case, where good behavior has been observed so far.

It is extremely important to do a permanent follow-up of patients who have suffered from this neoplasm, since ACC is a slow growing but relentless and unpredictable cancer, which favors metastatic evolutionary processes (1). Due to its rarity and lack of understanding of its molecular etiology, there is currently no standard chemotherapy for this neoplasm and many patients suffer from recurrent and/or metastatic disease. Therefore, the development of safe and effective therapies is imperative. In addition to conventional chemotherapies and angiogenesis inhibitors, the emergence of new therapies, such as immunotherapy and those targeting cancer trunks are expected to bring clinical benefits to patients in the future (19). On the other hand, in terms of diagnosis, it is possible to use immunomarkers such as CD117 when the normal morphology is similar to other pathologies (such as PA or PCA) in order to obtain confirmation of the diagnosis of ACC.

CONCLUSIONS

The diagnostic utility of CD117 immunohistochemistry for the differential diagnosis of ACC with PCA and even with PA is good and beneficial, especially in unusual locations such as the minor salivary glands of the upper lip, where benign glandular tumors are more frequent, allowing the establishment of adequate therapeutic protocols that favor the prognosis of patients and their adequate follow-up.

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TEACHING CONTRIBUTION

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Flipped classroom or master class: innovate or die

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ABSTRACT

The strategies to communicate information have undergone many changes, which have been evidenced in the pandemic. The idea is to be able to connect with the student and to get information across in a clear, timely and relevant manner so that the student has prior knowledge to integrate information from theory and practice to successfully face the simulated activity like when he or she interacts with the patient. In this context, the flipped classroom is a didactic strategy that provides videos, podcasts, among others, to be reviewed in advance, so that when the student participates in a face-to-face or virtual activity, the most important concepts are deepened and clarified, using active participation methodologies to achieve the following objective: Flipped learning seeks a change in the dynamics of learning that points to the student as its axis. The objective of this teaching contribution is to share the benefits of this strategy used with students of the Dentistry degree program within the framework of the Adult Stomatology Clinic I course taught in 2023 and which belongs to the fifth semester of the Stomatology degree program at the Universidad Peruana Cayetano Heredia.

Keywords: didactic strategies, flipped classroom, dental education.

INTRODUCTION

The teaching of the physical and mechanical qualities of dental biomaterials is a fundamental subject in the training of dentists. These materials are essential for dental restoration, rehabilitation and surgery; and their correct use is very important to ensure the health, esthetics and function of patients.

Dental education today faces a number of challenges, including increased academic load, student diversity, and the need to develop active learning skills. In this context, the flipped classroom (FC) strategy has become a promising alternative to enhance learning in dental education.

FC is a teaching methodology in which students learn the content independently, outside the classroom, and then deepen and apply their knowledge in the classroom. This strategy has proven to be effective in enhancing the learning of several topics, and in the case of the physical-mechanical qualities of dental biomaterials it can offer several advantages, such as:

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- Improve motivation: By learning the content independently, students can choose the resources and pace of learning that best suit their needs. This can help increase their motivation and reduce the feeling of academic overload.
- Encourage active learning: In a flipped classroom (FC), students are the protagonists of the learning process. Having to learn the content independently, they must reflect on the concepts and apply them in a practical way. This helps them develop critical thinking and problem-solving skills.
- Increase class participation: In the in-person classroom, after FC, students can explore the concepts and resolve their doubts. This allows them to participate more actively in the learning process.

This didactic strategy aims to improve the way of teaching and to generate significant learning, as well as to transform the teaching method. One of its strengths is that it is related to the strong links and interaction with the teacher, who generates activities that promote collaborative learning by peers and in a personalized way between students and teachers (1-3).

EXPERIENCE DEVELOPMENT

The use of information and communication technologies (ICTs) and new methodologies in the teaching process force the migration to more efficient and effective ways of learning, and one of them is the FC strategy. It was proposed as a change to traditional master classes, so the contribution of this experience was to encourage student participation and training in the personalization of autonomous learning.

The purpose was to generate a different, playful and innovative teaching experience to transmit information and achieve significant learning, as well as to promote the strengthening of the bond between teachers and students. Videos were made of two classes corresponding to the physical-mechanical qualities of dental biomaterials in the unit on dental caries and other types of dental deterioration in the Integral Adult Clinic I course given in 2023. Students received the links of the videos seven days before the learning session. They had to review the content of the videos as their personalized learning. A participatory activity was prepared in the class session, where participatory work between pairs was encouraged using social networks to achieve integration and appreciations regarding the content of the videos. Finally, a playful digital tool WordWall® (free version) was used to consolidate and provide feedback on the most important concepts. A FC survey was designed and validated by the teachers in charge. To determine the perception of the strategy, the survey was applied among students, in which they participated voluntarily and anonymously using Google Forms. Subsequently, a descriptive statistical analysis was performed.

RESULTS

65% of students participated (n = 60). Of those who participated, 71.7% were female and 28.3% were male. 85.2% were between 19 and 21 years old; 8.2% were over 22; and 6.6% were under 18. When asked if it was useful to have the class recorded before the face-to-face meeting, 60% felt it was useful; 36.7% felt it was very useful; and 3.3% mentioned it was not very useful. Regarding whether the face-to-face sessions with students and teachers were useful for learning about the topic, 52.5% considered that they were useful; 45.9% said they were very useful; and 1.6% disagreed that they were useful. When asked about the usefulness of the face-to-face activities, whether they were useful for learning the concepts provided in the videos, 50.8% agreed that they were useful; 42.6% strongly agreed that they were useful; 3.3% disagreed; and 3.3% strongly disagreed that the classes were useful in the face-to-face sessions. When asked whether the videos of the recorded classes were useful for learning the concepts provided, 54.1% considered that they were useful; 39.3% thought they were very useful; and 6.6% mentioned that they were a little useful.

When asked about their experience with this classroom modality, students expressed their impressions openly:

What is your opinion about your experience with these classes?

- *"I found it very different from the other classes I have in the course."*
- *"The dynamics of working in pairs and playing seem interesting to me."*
- *"I loved them because they are dynamic and catch your attention."*
- *"I find them interesting, and I feel it is easier to learn by watching a video before going to class and especially to learn by playing."*
- *"It's a class that activates me. I really enjoy participating even when the doctor asks for it, which compared to other theory classes of 2 hours, it seems as if they were 4 hours. The class with Dr. Saravia is very dynamic, he asks us to give our opinion and we also learn by playing, which is the best way to learn a topic in a faster way. Thank you, doctor!"*

- *"Didactics, adapted to the digital age".*
- *"Classes are a lot of fun with games that push you to pay attention."*
- *"They are really good because they are didactic. It is a technique for the student to interact and learn more than in a traditional class".*
- *"I find these classes interesting and important, but the environment in which they are conducted is sometimes not pleasant, not only for me, but for many of my classmates."*
- *"The experience in the proposed way was very fruitful; interaction is greater with students, something that allows the massive concentration of participants."*
- *"They were very dynamic and fun, they really caught my attention, apart from being very interesting."*
- *"These classes are very didactic, entertaining and above all, they give you the possibility to learn in different ways, such as with audio, video and quiz games".*
- *"Learning was very dynamic and interactive with images, questions and examples given in class."*
- *"Podcasts and videos are helpful in a complementary way to recall concepts, and I really like the fact that we can use technology to develop this information."*
- *"I really like the class because it's different from what we're usually used to."*
- *"They were very interesting."*
- *"I found it didactic, I liked the teaching method."*
- *"I like it a lot because it is didactic; when I play certain learning games I learn better."*
- *"I really like the way the doctor explains, it's very interactive and understandable."*

DISCUSSION

The results of this experience showed that the FC didactic strategy was efficient in generating significant learning in students, who showed a higher level of understanding of the concepts and were more motivated and participative in class. This is related to what has been found in the literature, where, in order to foster critical thinking, problem-solving skills and commitment to new ways of teaching and learning are promoted (1, 4, 5).

Motivation in learning

Motivation is an indispensable variable for learning. When students are motivated, they are more likely to connect with the content of the class and remember the information provided. In the case of the physical-mechanical qualities of dental biomaterials, motivation can be a challenge. These concepts can be complex and abstract, and it is important that students understand their relevance to clinical practice (6).

FC can help improve motivation for learning this topic. By allowing students to learn the content autonomously, they can choose the resources and pace of learning that best suit their needs. This helps them feel more independent and in control of their own learning. Apart from that, FC helps students realize the relevance of the concepts they are learning. When relating concepts to clinical practice, they can better understand their importance and their application in the real world (1).

Creativity in learning

Creativity is an essential skill for success in education in general, but particularly with dental education as well as in professional life. Physicians need to be creative to solve problems and offer innovative solutions to their patients. FC can help foster creativity in learning. By allowing students to learn independently, they can explore different ways of learning and applying knowledge. This helps them develop their critical thinking and find original solutions to problems (1, 7).

In the case of the physical-mechanical qualities of dental biomaterials, creativity can help students to better understand concepts; for example, students can create models or simulations to represent concepts.

Learning transformation

Learning should be transformative. Students should have the ability to put knowledge into practice to learn with simulated or real situations. FC can help transform learning. By allowing students to learn independently, they can delve deeper into concepts and apply them in a practical way. This helps them develop transferable skills that they can apply in different contexts (1, 8).

In the case of the physical-mechanical qualities of dental biomaterials, FC can contribute with students to develop diagnostic and treatment skills; for example, students can use the acquired knowledge to assess the condition of a tooth and recommend the appropriate dental material (1, 9-12).

CONCLUSIONS

FC is a promising methodology for teaching the physical-mechanical qualities of dental biomaterials. This strategy can help improve motivation, creativity, connectivity and learning transformation. Undoubtedly, this didactic strategy provides the opportunity to consider a new way of connecting with students, one that is closer to the new disruptive

methodologies that promote active and collaborative learning between students and teachers, generating the possibility of autonomy in learning.

The way we learn has changed and the way we teach has also changed. Along with these initiatives, new opportunities and challenges arise to analyze the relevance or not of continuing with the master class as a strategic model for transmitting information or migrating to a new way of teaching, as is the case of FC. Undoubtedly, innovating with FC or dying with the classic ways of transmitting information are the new challenges posed by the art of teaching. Now that their benefits are known, and considering even more the different learning styles, there is no doubt that we can achieve unique success using FC.

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LETTER TO THE EDITOR

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Radiation shielding in dentistry? Comments on the study by Daniel Pinto Agüero (2023)

Jorge Homero Wilches-Visbal[1, 2, a], *Kewin William Lázaro-Sandoval*[3, b], *Midian Clara Castillo-Pedraza*[1, c]

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Dear Editor,

We have read with great interest the letter by Pinto Agüero (1), entitled "Is radioprotection necessary in dentistry?", in which he points out that, although digital radiography brings advantages in terms of radiological safety, exposure time, image quality and communication, it is not yet a reality in Latin America due to its high cost, among other reasons. He also argues that, for reasons that are widely known, it is not advisable to follow the worldwide trend in medicine of not using lead aprons. To support this assertion, he cites the recent European Consensus on Patient Contact Shielding (ECPCS) study (2). However, he did not give details and/or did not specify the ECPCS considerations regarding the use (or lack of use) of different types of shielding in dental radiographic examinations. In this sense, the authors of this letter intend to extend the discussion on a subject of utmost importance as this one.

The criteria established by ECPCS for the recommendation (and justification) of shielding (thyroid, ocular, breast and fetal) in medical and dental radiographs are as follows: i) "They should be used" (there is evidence that the use of shielding is beneficial and effective); ii) "They can be used" (there is an agreement that the use of shielding may be beneficial in certain circumstances); and iii) "It is not recommended" (there is evidence or agreement not to use it).

As pointed out by Dr. Pinto (1) and other authors (2, 3), the proximity of the field of view (FOV) to radiosensitive organs of the head and neck, such as the thyroid, the salivary glands, and the oral mucosa of the patient, together with the high frequency of dental radiographic examinations, especially those related to pediatric patients, means that removing the shielding in oral radiographs is not a generalized practice in this area. In this regard, ECPCS mentions:

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1. The thyroid collar is "not recommended" in any case within the FOV, except in cephalometry when the cervical spine does not have to be evaluated.
2. The thyroid collar "can be used" in intraoral radiography, cephalometry or Cone Beam Computed Tomography (CBCT) if it is outside the FOV (to avoid artifact generation or overexposure in automatic exposure systems), prior consultation with a medical physicist.
3. Breast and eye shielding is "not recommended" in any case, either outside or inside the FOV. In the breast, it has been found that it can even increase the dose in the breast and in neighboring organs such as the lungs. In the eyes, despite being the most radiosensitive organ, it would be best to employ a dose reduction strategy rather than shielding, except perhaps in fluoroscopically guided interventional brain procedures.
4. The leaded apron for fetal protection is "not recommended" in any type of radiography, either inside or outside the FOV. The reason is that most of the radiation received by the fetus does not come from the primary beam, but from scattered radiation in the mother's internal tissues. Ideally, a dose optimization strategy should be applied. Furthermore, ECPCS does not consider it pertinent to use a lead apron to reassure apprehensive patients because that would mean accepting, before the patient and the community, that the risk of radiation is exaggerated in radiodiagnosis. Efforts should focus on explaining the risks of using shielding.

Based on the ECPCS report and our expertise and professional experience, we can conclude the following: (i) the standard is that it is not necessary to use any type of shielding in dental radiographic examinations; (ii) optimization is the best dose reduction strategy (e.g., good beam collimation, high kilovoltage, preferring manual over automatic control equipment, among others); (iii) explain in advance what the procedure consists of and what the associated risks are to avoid radiophobic events, using even web or mobile applications (4); (iv) receive ongoing training and advice on radiation protection from a medical physicist or radiation expert; v) consider approaches, scenarios, and individual circumstances in which shielding could provide a net benefit to the patient; and vi) it is essential that the institutions providing these services have quality assurance programs in place to evaluate the repeatability of the variables associated with the imaging techniques, such as applied kilovoltage, reproducibility of exposure times, quantification of skin dose and equipment performance. Additionally, it is suggested to establish reference levels by entity or city to reduce the radiation doses administered to patients without affecting the quality of the diagnostic image.

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LETTER TO THE EDITOR

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Artificial intelligence in maxillofacial radiology: threat or tool?

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Dear Editor,

In 1975, Allen Newell and Herbert Simon, recipients of the prestigious Turing Award, formulated the physical symbol system hypothesis, which can be summarized as follows: "every physical symbol system possesses the necessary and sufficient means to carry out smart actions". Artificial intelligence (AI) is then in charge of verifying this hypothesis using digital computers.

In medical and dental science, the anticipated potential use of AI as a diagnostic tool is, with an eye to the future, limitless. Particularly in maxillofacial radiology, whose rapid progress is based precisely on the use of computers, it can even have a greater benefit, given the number of interpretative support applications, thus enhancing the diagnostic capacity of the professional specialist, improving times and increasing the assertiveness in their judgment, which will be based on easily quantifiable data.

The support provided by this technology should be wisely used and incorporated into the daily workflow of an imaging center. At the same time, it will aim to provide better health care with the legal backing of a trained and accredited professional who shall, in turn, ensure the ethical use of the database, ensuring the confidentiality of the information and, if it is centralized, the professional will be able to work together with others without any barrier of physical distance as an impediment to make dental diagnosis even more efficient and practical in order to provide a better health condition.

It is in the interest of AI to develop systems that think like "humans think" to perform tasks that we would normally do. There is no evidence that AI is (or will ever be) superior to human intelligence (1). Therefore, in the era of specificities and subspecialties, having "intelligent" imaging support in high-flow dental medical care will be a real tool to support the radiologist's overdemand and physical exhaustion. Staying away from this aid seems —*a priori*— a nonsense that should, at least, be re-evaluated by each specialist today.

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In maxillofacial radiology, utilities —with different levels of efficiency, compared to the diagnostic capacity of the human being— are varied. These systems require labeled data previously fed by a human expert, a field of AI called Machine Learning (ML), in which the machine creates an algorithm by which it can classify what it sees using feature engineering. In turn, Deep Learning (DL), a subfield of ML, makes use of a convolutional neural network (CNN), by which it can automatically learn the algorithmic function from labeled data, without human intervention, learning finally by itself.

For the time being, AI can provide additional recognition capability in interproximal caries lesions or periapical pathologies through three tasks: i) "classification" to binary categorize an image between "healthy" or "caries lesion" tooth; ii) "detection", drawing a box on the image near the caries lesion boundaries; iii) and "segmentation", which results in almost perfect color delineation of the carious lesion, with precision in the pixels bordering it (2). Without going back in time, with respect to cephalometric analysis, the recognition of anatomical landmarks and the classification of skeletal relationships use since 1998 the identification of anatomical landmarks with algorithm-based methods. And in 2014, the automated identification of 3D anatomical landmarks is used, thus overcoming several shortcomings of 2D image analysis, such as projection errors, object magnification and overlapping of structures. On the other hand, in legal dentistry, advances have been demonstrated with the use of CNN to estimate age by stratifying the development of the third molar corresponding to the Demirjian classification in panoramic radiographs, whose use in forensic sciences can contribute enormously, at the time of identification, through dental organs of victims in large-scale disasters where bodies have been severely mutilated (3).

As can be seen, AI has been surreptitiously accompanying us for decades, safely supporting us in tasks that, without its help, would delay diagnosis and lengthen treatments. So why should we hesitate over the benefits of a breakthrough that has so far been an excellent ally? Our humanity lies in chemical interactions and, with the environment, it is an accumulation of things impossible to objectify, some even transient and intangible, whose existence we know and admit as ours, and in some cases they govern our lives. It is these human essences, which Gerd Leonhard calls "androrhythms" (similar to computational algorithms), that we must —as healthcare and therefore service professionals— protect, even if this makes us inefficient in comparison with non-biological systems. Technology will always be there for human beings, and not the other way around (4).

Legal and bioethical implications and limitations that AI implies are and will be constant reflections where multiple actors should be considered, so that technical and scientific advances do not affect intellectual development or the things that make us human.

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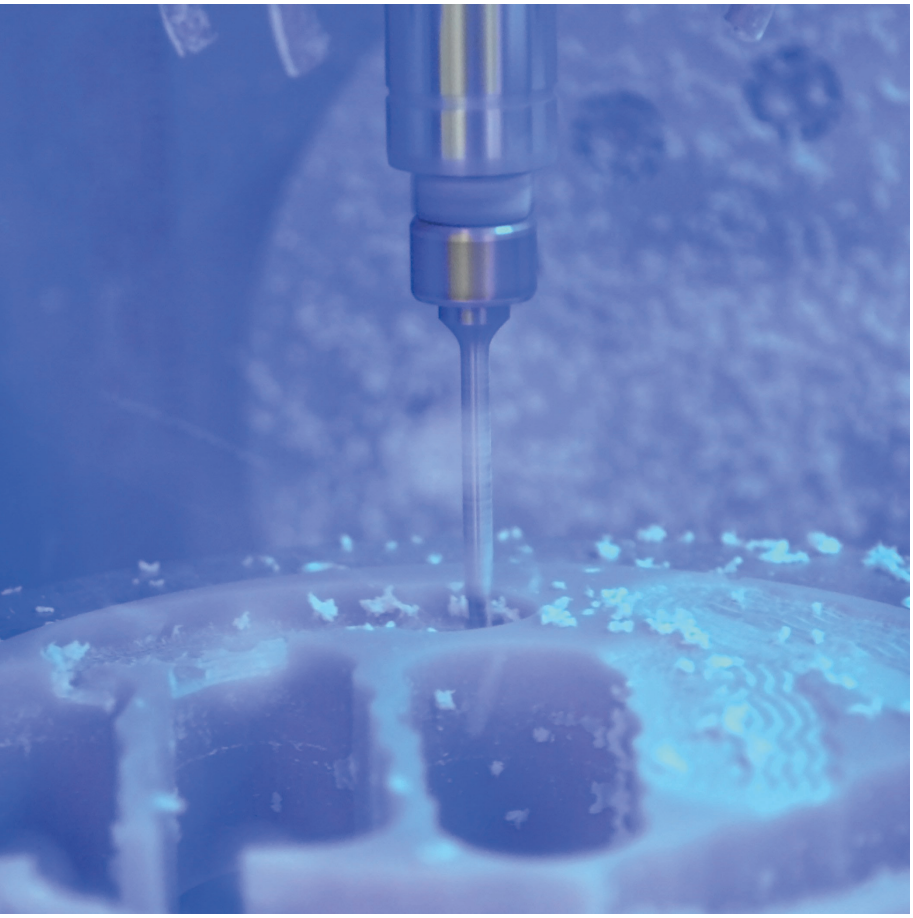

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