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EDITORIAL

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Dr. Carlos F. Cáceres
Vice-Rector of Research at Universidad Peruana Cayetano Heredia

The role of university research: a reflection*

Dr. Carlos F. Cáceres [1]

Dear authorities of the university and of the Facultades de Medicina, Estomatología y Enfermería, directors and members of the different departments of the university and of those faculties, professors, researchers, and students of the university:

We are here to award internally funded research grants won in a competitive process. It is a pleasure to reaffirm the commitment of our faculties and of the university to research, and thus confirm the identity of a research university such as ours.

You must have learned that two dominant profiles of the modern university institution were configured in Europe during the 19th century: i) the French Napoleonic model focused mainly on the solid education of many citizens; and ii) the German Humboldtian model, featuring the centers in which knowledge was produced, and they taught what they produced. This was the model that, at the end of the 19th century and beginning of the 20th century, gave rise to the Great Research Universities in the United States. It was about those universities that conduct important research and that nowadays are considered great universities in that country. Independent of San Marcos, the emerging Cayetano of the 1960s had enough lineage in terms of researchers and collaborative connections to be the first research university in Peru. And over time, despite the challenge of our chronic financial limitation, Cayetano has been consolidating as such.

The growing competition among universities, derived from the onslaught of corporate companies, influences the evaluation of research, whose bibliometric logic is degraded and becomes susceptible to the effect of regrettable forms of authorship and patent trafficking that have been destroying this system, as they have led to certain levels of tolerance for the lack of scientific integrity of researchers that can be observed in many centers. Cynical commercial and labor pressures, at the institutional and individual level, end up caricaturing the current merit indicators and affecting serious institutions such as ours, which could no longer count on

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*Remarks from the Vice-Rector of Research at Universidad Peruana Cayetano Heredia at the winners ceremony of the Research Support Fund of the Facultades de Medicina, de Estomatología y de Enfermería.

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the *rankings* as relevant references and would have to advocate the use of other more appropriate indicators. We could say that all this happens in a world that, by frivolously extolling research as infallible, ends up forgetting that what it represents is an endless search for truth, which we believe we are getting closer to, but which is, by definition, unattainable. Indeed, all our scientific truths are temporary truths —as Thomas Kuhn explained—, which will eventually be falsified in new studies, according to Karl Popper's epistemology. This is something we should always remember when we feel compelled to despise other forms of knowledge that are less systematic but each possessing its own richness. An extreme version of such arrogance is scientism, a form of cult of scientific knowledge that ends up dogmatizing it, thus denying the very nature of science itself.

And in this context, let us keep in mind that the current university system encourages us to forget that many research projects that discover or create technology will have an impact on society only if we complete technology transfer processes, which applies not only to devices, but also to synthetic drugs and other patentable results. And, finally, the convulsions of today's world should not make us forget the importance for science to respect the criteria of research ethics, which derive from the promise adopted at Nuremberg, to the effect that knowledge tainted with the violation of the human rights of participants in a study will never ever be produced again, a promise that now tends to include the disproportionate and unjustified suffering of experimental animals.

The departments of the Vice-Rectorate for Research try to support researchers on these and other issues. Visit us. Congratulations to all faculties, the Unidad Integrada de Gestión en Investigación, Ciencia y Tecnología (UIGICT) and all winners for their efforts. We hope you can reach a good conclusion.

Thank you very much.

ORIGINAL ARTICLE

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Position accuracy of short abutment analogs in the working model splinted with dental floss versus Bis-acryl bars in total edentulous mandibles

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LFHO: conceptualization, research, project management, resources, software, visualization, writing of original draft, writing – review & editing.
CMM: supervision, validation, visualization.
LDC: conceptualization, data curation, formal analysis, methodology, software, supervision, validation, visualization.

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ABSTRACT

Objective: To compare *in vitro* the positional accuracy of short abutment analogs splinted with dental floss versus short abutment analogs splinted with Bis-acryl bars as a preliminary step to obtaining the working model in the preparation of implant-supported prostheses in total edentulous mandibles. **Materials and methods**: An aluminum master model simulating an edentulous mandible with five analogues was prepared. Using a customized tray and, by means of a technique for fixing the transfers to it, thirty impressions were recorded, which were divided into three groups: WS group (without splinting), SDF group (splinting with dental floss) and SBB group (splinting with bis-acryl bars). Subsequently, a digital indoor micrometer was used to perform distance and height measurements between analogs. The statistical tests used were Shapiro-Wilk, ANOVA and Tukey's *post hoc*. **Results:** For distance measurements, no statistically significant differences were found between groups ($p = 0.674$). For height, statistically significant differences were found between groups ($p < 0.001$). Bis-acryl presented differences with the WS and SDF groups ($p < 0.001$). **Conclusions:** Splinting of short abutment analogs did not show significant differences in the distance measurement; however, it did present differences in the height measurement, specifically between the SBB and WS groups, as well as between SBB and SDF groups.

Keywords: dental implants; dental prosthesis; dental impression techniques; dental floss.

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INTRODUCTION

The surgical protocol proposed by Branemark determines the basis of osseointegration implant surgery. These precepts aim to achieve the best biological conditions to promote implant osseointegration (1). After the surgical procedure, the prosthetic phase takes place, in which a definitive impression is made. Impression is defined as a negative image or reverse copy of the surface of a body. In implant prosthetics, it is also called transfer. In addition, there is standardization of the components used for this purpose, since we know the dimension of the platform of the implant placed, which presents a perfectly adequate impression component called transfer (2, 3).

Transfer is the element of an implant system used to provide the spatial relationship between an endosseous dental implant and the alveolar ridge, as well as the dentition or other adjacent structures. Also named impression copings, these can be trapped in the impression or require manual transfer or repositioning. They are used intraorally for the impression record and then the analog or replica is attached to it (2, 3). This is how the abutment platforms in the patient's mouth are emulated by means of analogs in a structure made of plaster, which must faithfully reproduce their three-dimensional location. Gallucci et al. (4) used impressions made in eleven edentulous segments with the open and closed tray technique, without finding a significant difference between them. However, Nakhaei et al. (5) compared these techniques and found the open-tray impression technique to be the most accurate.

There are certain factors that alter the obtaining of accurate study models, such as the dimensional changes of the plaster during setting and the inadequate selection and handling of the impression material (6-10). An accurate working model will provide passive settlement of the metal framework, avoiding mechanical failure and biological complications around the implants (11-16). Currently, several techniques have been suggested for the splinting of transfers, prior to casting, which would improve the accuracy in the reproduction of the location of the abutments in the working model (12). The splinting technique stabilizes the copings during impression to prevent rotational movements and, in turn, reduce the dimensional changes caused by the impression material in the model making process (12, 13). Regarding complete edentulous situations with 4 or more implants, splinted impressions have been shown to be more accurate than unsplinted impressions (14, 17-21). A low shrinkage resin can be used for splinting, mainly indicated for precision soldering procedures (20, 21). Similarly, self-curing resins with high flexural strength can be used, indicated for the fabrication of long-lasting temporary resins (19, 22, 23).

Considering that the impression technique with transfer splinting offers high accuracy in the fabrication of implant prostheses compared to impression techniques without splinting, it is important to mention that previous evidence on the splinting of analogs prior to casting the working model is scarce. Therefore, the aim of this study was to compare *in vitro* the positional accuracy of short abutment analogs splinted with dental floss versus short abutment analogs splinted with Bis-acryl bars, as a preliminary step to obtaining the working model in the fabrication of implant-supported prostheses in total edentulous mandibles.

MATERIALS AND METHODS

For this *in vitro* study, 30 working models of total edentulous mandibles were made in plaster type IV (Elite Dental Stones®, Zhermack SpA, Rovigno, Italy), following all technical specifications of the Branemark Protocol, randomly distributed in three groups (n = 10): without splinting (WS) (as a control group for comparison of the groups under evaluation), splinting with dental floss (SDF), and splinting with Bis-acryl bars (SBB) (Figure 1). The sample size was selected on a non-probabilistic basis.

Figure 1. Analog splinting techniques. A) group without splinting (control group); B) group splinted with dental floss (SDF); C) group splinted with Bys-acryl bars (SBB).

The pattern model of the lower mandible was designed to simulate an edentulous mandible with multiple implants, representing a hybrid prosthesis on implants, since this type of prosthesis presents greater challenges during the transfer impression (Figure 2). Miniabutment analogs were placed in the standard model, following a specific distribution: The distal analogs were located 2 mm in front of the position of the mental foramen (A, E). The central analog (C) was located at half the distance of analogs A and E. The fourth analog (B) was located at half the distance of analogs A and C. And the last one (D) was located at half the distance of analogs C and E.

Figure 2. Pattern model scheme and distribution of analogs.

All analogs were placed at right angles between the axial axis with respect to the base of the standard model. The model had four positioning extensions on the anterior, posterior and lateral surfaces of the base, which served to standardize the reproduction processes. A 2 mm thick acrylic tray was made, with perforations to position the transfers and notches to fit the extensions, allowing free space for the impression material to run off.

Tray adhesive was applied, and addition silicone of regular and heavy consistency was used for the impression. Excess material that overflowed was cut with a No. 15 scalpel blade (Surgical Blades Swann

Morton, Shefield, England). Subsequently, the transfers were bonded with acrylic resin (GC Pattern Resin® Low Shrinkage Modelling Resin, Alsip, USA) to the impression tray, and the transfers were unmatched for complete removal of the impression from the pattern model. This procedure was repeated to obtain a total of 30 impressions. The impressions were cast with type IV extradrystalline plaster (Elite Dental Stones®, Zhermack SpA, Rovigno, Italy), using the ratio of 20 mL of water per 100 g of powder, established by the manufacturer in a vacuum mixer (Elite® Mix Zhermack, Polesine, Italy).

The distance measurements between the abutment analogs were performed taking as reference the axial axis of each of the analogs, for which a digital inside micrometer (Digital Inside Micrometer, range: 5-30 mm, Insize, Suzhou, China) was used. The segments in which the measurements were taken were as follows: AB, AC, AD, AE, BC, BD, CD, CE, DE, EB (Figure 3B). For the measurement of the height of each analog, the top of the flange and the highest end of each abutment analog were taken as a reference.

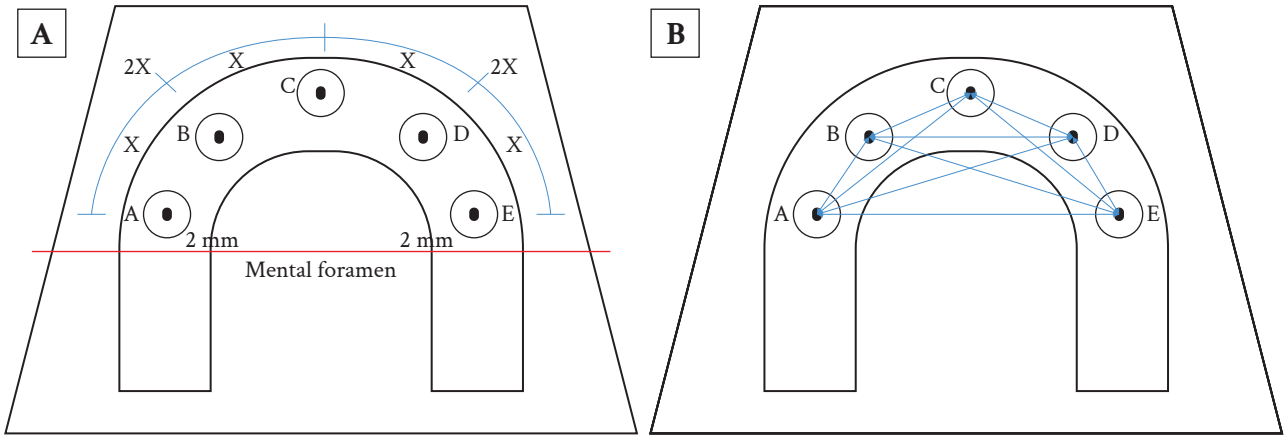

Figure 3. Analogue position scheme. A) Distribution of analogues; B) Measurements made on the standard model.

A descriptive analysis was performed to verify the metric variations of distance and height between the analogs, and the normality of the data was verified with the Shapiro-Wilk test. An ANOVA and Tukey's post hoc statistical analysis was also carried out to contrast the means of the metric variations in distance and height according to the splinting groups, using the SPSS 25.0 statistical program. The study had a confidence level of 95% and a $p < 0.05$. As it was an *in vitro* study, permission was obtained from the University Board of Regulatory Research Affairs of the Universidad Peruana Cayetano Heredia (DUARI-UPCH).

RESULTS

Distance and height values of the three groups are shown in Tables 1 and 2. In terms of distance, the mean of the WS group was 24.914; the mean of the SDF group was 24.929; the mean of the SBB group was 24.921; and the mean of Pattern was 24.925, where no statistically significant differences were found ($p = 0.674$) (Table 1).

Table 1. Distance measurements per segments (in mm).

Segment	Without splinting (WS)			Dental floss (SDF)			Bis-acryl (SBB)			Pattern
	X	SD	Dif.	X	SD	Dif.	X	SD	Dif.	
AB	11.282	0.021	0.000	11.316	0.023	0.034	11.288	0.031	0.006	11.282
AC	26.000	0.029	0.012	26.012	0.033	0.000	26.014	0.031	0.002	26.012
AD	36.248	0.041	0.015	36.292	0.032	0.029	36.287	0.027	0.024	36.263
AE	40.684	0.017	0.019	40.672	0.042	0.007	40.653	0.033	0.012	40.665
BC	16.024	0.026	0.043	16.011	0.036	0.056	16.029	0.026	0.038	16.067
BD	29.300	0.028	0.014	29.320	0.028	0.006	29.314	0.034	0.000	29.314
BE	36.325	0.043	0.016	36.347	0.040	0.009	36.341	0.024	0.003	36.338
CD	16.043	0.024	0.013	16.063	0.020	0.007	16.035	0.035	0.021	16.056
CE	26.024	0.031	0.015	26.032	0.030	0.007	26.016	0.026	0.023	26.039
DE	11.210	0.028	0.006	11.223	0.036	0.007	11.234	0.035	0.018	11.216

X: Mean; SD: Standard deviation; Dif.: Difference with pattern.

In terms of height, the mean of the WS group was 5.188; the mean of the SDF group was 5.176; the mean of the SBB group was 5.214; and the mean of Pattern was 5.179, where statistically significant differences were found ($p < 0.001$).

Table 2. Height measurements per segments (in mm).

Segment	Without splinting (WS)			Dental floss (SDF)			Bis-acryl (SBB)			Pattern
	X	SD	Dif.	X	DE	X	SD	Dif.	X	
A	5.335	0.010	0.007	5.307	0.040	0.035	5.378	0.056	0.036	5.342
B	5.132	0.005	0.027	5.120	0.007	0.015	5.170	0.029	0.065	5.105
C	5.147	0.018	0.040	5.132	0.010	0.025	5.161	0.030	0.054	5.107
D	5.188	0.023	0.005	5.196	0.011	0.013	5.190	0.020	0.007	5.183
E	5.138	0.007	0.025	5.125	0.005	0.012	5.170	0.032	0.057	5.113

X: Mean; SD: Standard deviation; Dif.: Difference with pattern.

When comparing the height groups, the SBB group showed a difference with the WS and SDF groups ($p < 0.001$) (Table 3).

Table 3. Mean distance and height measurements between groups (in mm).

	Without splinting (WS)	Dental floss (SDF)	Bis-acryl (SBB)	Pattern	p
Distance	24.914	24.929	24.921	24.925	0.674*
Height	5.188[a]	5.176[ab]	5.214[ab]	5.170	<0.001*

* ANOVA test.
** Tukey's post hoc test: equal letters represent statistically significant differences ($p < 0.05$).

DISCUSSION

The main objective of the study was to evaluate the positional accuracy of splinted short abutment analogs using two different methods: dental floss and Bis-acryl bars, including a control group without splinting. This step is considered critical in the manufacture of the working model used in implant-supported prostheses for total edentulous mandibles. Precision in the working model is fundamental, as it serves as the basis for the creation of the metal structure. The correct adaptation of this structure is essential to avoid the transmission of harmful forces to the implants, which could lead to both mechanical and biological complications, including the loss of implants in the oral cavity.

In relation to distance, our results revealed no significant differences between the splinted and unsplinted analog groups. However, significant differences were observed in the height dimension, where the splinting material using Bis-acryl showed lower accuracy compared to the splinted group without floss and the unsplinted group. Although we did not find specific papers in the literature that present results on analog splinting, there are investigations on the splinting of transfers that can serve as a reference, since they involve a similar splinting technique. Despite the differences between the procedures, the results of these studies are comparable, since in both cases the aim is to immobilize certain parts of interest.

In this regard, it is relevant to mention the previous studies of Herbst et al. (23), in 2000, who found no significant differences between splinted and unsplinted transfers, as well as the findings of Papaspyridakos et al. (24), in 2012, who stated that the splinting technique led to more accurate plaster models in implant-supported fixed prostheses in edentulous mandibles. Although our study did not reveal significant differences in distance between the groups analyzed, significant differences in height dimension were observed in the group that used Bis-acryl as splinting material, and this discrepancy could be related to the study conducted by De Avila et al. (12), in 2014. These researchers indicated that the use of bur shanks produced excellent results due to the rigidity of the material (stainless steel), which does not undergo expansion or contraction, in contrast to resins, which tend to contract during the polymerization process.

It is important to note that the printing technique used in our study was based on the approach described by Lanis et al. (16), in 2015, where transfers are splinted by attaching them to a customized tray. Despite providing adequate accuracy, this technique has some clinical disadvantages, such as the need to keep the tray in the mouth during fixation of the transfers, which could lead to distortions. This approach is supported by the results of the study by Torres (25), in 2017, who compared various splinting techniques for impressions, including the technique of transfer fixation to the tray, previously described by Lanis et al. (16) in 2015. The findings of Torres (25) suggest that the technique of fixing transfers to the tray with acrylic resin outperforms splinting transfers with acrylic resin-coated dental floss in terms of precision.

The lack of significant difference in the distance between the pattern and the evaluated groups could be explained by an adequate impression technique, which provides the necessary confidence to carry out the subsequent conventional steps without the need to perform additional procedures before pouring the working model. Hoods-Moonsammy et al. (26), in 2014, established a maximum limit of mismatch in passive settlement of the metal superstructure of 0.150 mm before performing the installation of the prosthesis in the mouth. Our study showed that, regardless of the splinting technique used, all groups showed values below this baseline figure.

Considering these results, the question arises as to whether splinting of analogs is a necessary laboratory procedure. This question is aligned with the conclusions of a study carried out by Poquioma (27) in 2016. This author evaluated the splinting of short abutment analogs in the fabrication of total edentulous mandible models using acrylic resin bars and acrylic resin-coated dental floss. Their results indicated that there was no significant difference in distance or height between the groups tested.

No statistically significant differences were observed in the distance segments between the analogs, but significant differences were found in the height dimension, especially in the group that used Bis-acryl as splinting material. This finding could be attributed to exothermic changes during the polymerization process of the material, which are related to the reaction of its vinyl groups. Ha et al. (28), in 2011, suggested that these changes could be related to resin volume. Additionally, a previous study by Kim and Watts (29), in 2004, indicated that the shrinkage coefficient of Bis-acryl Luxatemp Star® (DMG) is in the range of 3.31-3.64%.

Apart from that, the lower precision in splinting could be attributed, particularly in the case of the Bis-

acryl bar technique, to the difficulty of this procedure for the operator. This is compounded by the time required to carry it out, which translates into greater effort and, ultimately, higher economic costs due to the limited accessibility of the material. Since Bis-acryl is mainly used in the creation of mock-ups in routine clinical practice, its use in this type of procedure could be considered complicated and even questionable in terms of relevance. Finally, it is relevant to mention the study by Matta et al. (30), in 2017, who reported that the implementation of digital impressions could potentially replace conventional procedures, as it leads to improvements in the accuracy of CAD-CAM fabrication of superstructures.

The *in vitro* nature of the experimental design may not fully reflect actual clinical conditions. In addition, the specificity of the material and models used may limit the generalization of findings. Finally, the splinting technique used may not be fully representative of all clinical practices. Despite these limitations, the study provides valuable information on the accuracy of splinted short abutment analogs, contributing to the knowledge in implant-supported prosthodontics in total edentulous mandibles.

CONCLUSION

Splinting of short abutment analogs did not show significant differences in the distance measurement; however, it did show differences in the height measurement, specifically between the SBB and WS groups, as well as between SBB and SDF.

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ORIGINAL ARTICLE

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Comparison of the penetration of three endodontic sealers into dentinal tubules with scanning electron microscopy

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ABSTRACT

Objective: To compare *in vitro*, using a scanning electron microscope, the penetration of three endodontic sealers: made of epoxy resin (AH Plus®), of polydimethylsiloxane (Roekoseal®), and of calcium hydroxide (Apexit Plus®) into the dentinal tubules at 3 mm and 7 mm from the root apex, with the lateral compaction technique in uniradicular lower premolars. **Materials and methods:** *In vitro* study. Thirty-six teeth were prepared and divided into three groups of 12 teeth each. All the teeth were prepared and each group was obturated with three different endodontic sealers. Subsequently, the teeth were cut transversely at 3 mm and 7 mm from the root apex; then they were prepared to be taken to the scanning electron microscope to observe the penetration of the sealers in the dentinal tubules. **Results:** ANOVA test was used to compare the 3 groups and Student's t-test was used to evaluate the penetration of each of the sealers at 3 mm and 7 mm. Tukey's *post hoc* test was also performed to evaluate between sealer groups. When comparing the 3 groups of endodontic sealers, greater penetration was found with the Roekoseal® sealer at 3 mm with a statistically significant difference, ANOVA test ($p = 0.04$). When comparing each of the sealers at 3 mm and 7 mm, significant differences were only found ($p = 0.04$) in AH Plus®, showing better penetration at 7 mm with respect to 3 mm; and when the sealer groups were compared, both at 3 mm and 7 mm, no statistically significant differences were found. **Conclusions**: All three sealers evaluated *in vitro* penetrated in the dentinal tubules. At 3 mm, the Roekoseal® sealer outperformed the other two sealers; and at 7 mm, there was no significant difference between them.

Keywords: root canal filling; root canal filling materials; dental marginal adaptation.

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INTRODUCTION

Root canal obturation is based on the use of semi-solid gutta-percha cones accompanied by an endodontic sealer (ES), since these cones alone do not completely seal the root canal system (1). ES are inert or therapeutic substances that complement the obturation of the root canal, fixing and adhering the gutta-percha cones to each other and to the dentin walls of the root canal, thus eliminating empty spaces. ES, together with the cones, provide the essential hermetic sealing especially for the apical zone. Sealants must be stable and must be able to enter the side, secondary and accessory canals of the canal system where gutta-percha cannot enter (2, 3).

ES should also penetrate the dentinal tubules, which is considered a desirable result, as it increases the interface between the canal walls and the gutta-percha, thus improving the hermetic seal (3). A significant advantage of ES penetration is the isolation of the nutrient source to viable bacteria within the dentinal tubules, which favors their antibacterial effects (4, 5).

Numerous variables, including the existence of the dentin mud layer, dentin permeability, dentin tubule diameter, root canal branches, and the physical and chemical characteristics of the sealant, can influence the depth of ES penetration into the dentin tubules (6).

Several ideal characteristics or requirements that ES should possess have been established. Grossman (7) mentions the following: provide good adhesion between gutta-percha and root canal walls; have a tight seal, easy to insert into the root canal; adequate working time; be sterile or easy to sterilize prior to placement; be radiopaque; possess dimensional stability upon setting; do not pigment the dental piece; do not suffer corrosion; be bacteriostatic, or do not facilitate bacterial growth; be well tolerated by periapical tissues (biocompatibility); be insoluble in oral fluids but soluble in a solvent so that it can be removed if required. Lioni (8) defines that ES must be homogeneous when mixed, to promote better adhesiveness, be resorbable in case of overfilling, stimulate the formation of repair tissue, and without being cytotoxic, mutagenic or carcinogenic.

This study will contribute with knowledge to identify which ES has the best penetration capacity in the root canal irregularities and dentinal tubules, in order to use the appropriate one, according to the diagnosis and the treatment plan proposed, thus helping the achievement of the patient and the professional. In this sense, the purpose of this study was to compare the *in vitro* penetration in micrometers of three ES, one based on epoxy resin, another on polydimethylsiloxane and the last one on calcium hydroxide, in the dentinal tubules, for which a scanning electron microscope was used.

MATERIALS AND METHODS

The study was *in vitro*. A pilot study was conducted and the mean comparison formula was used to determine the sample size of 12 uniradicular premolar teeth for each ES group. All teeth had to meet the following inclusion criteria: uniradicular human teeth, teeth with a fully developed canal, teeth with a single canal, teeth with an adequate length, with a minimum of 15 mm of root length remaining after decoronation. And the exclusion criteria were as follows: teeth with coronary and/or root fractures, teeth with previous endodontic treatment, teeth with calcified and/or atresic canals, teeth with moderate or severe curvatures, teeth with root resorptions, and teeth with immature apices.

The teeth were placed in a jar containing a 1% sodium hypochlorite solution for four hours (9). Hand scrapers were used to carefully remove calculus or soft tissue remnants from the root surface. Subsequently, the teeth were preserved in jars containing saline solution at room temperature until the time of use (10). To confirm the presence of a single canal, periapical radiographs were taken of the selected teeth in the vestibulo-lingual and proximal direction.

Procedure sequence

The teeth were cut at the cementoenamel junction with a carborundum disc (dentorium) using a Lynx™ low speed motor (USA). The length of the tooth was standardized to 15 mm. A number 10 K file (Maillefer-Dentsply) was introduced into the root canal until the tip is visible in the apical foramen. This measurement was reduced by 1 mm to obtain the working length. With the radiovisiograph (RVG), the corresponding conductometry was performed with a number 15 K file, and in some teeth a number 20 file was used.

Biomechanical preparation was performed with Mtwo® system rotary files (VDW, Munich-Germany) according to the manufacturer›s recommendations. It was instrumented up to a 40.04 Mtwo file, and finished with an ISO 45.02 manual file, at a working length of 14 mm. Irrigation was performed using NaviTip needles with 2 mL of 2.5% sodium hypochlorite (NaOCl) for each instrument used. Once the biomechanical

preparation was completed, a K ISO 15.02 file was extruded through the apical foramen to make sure that the root canal was not obstructed. Final irrigation of the root canals was performed with 3 mL of 17% EDTA (Biodinamica Quimica, Brazil) for 3 min, followed by 3 mL of 2.5% NaOCl to remove the smear layer (11, 12).

Three groups of 12 teeth each were formed to be filled with three different ES: group 1 with ES AH Plus® (Maillefer-Dentsply), group 2 with ES Roekoseal® (Coltene-Whaledent) and group 3 with ES Apexit plus® (Vivadent-Ivoclar). In terms of the Roekoseal® ES group, 3 mL of 95% ethyl alcohol was added to the final irrigation (10, 13). Two teeth were prepared and used as negative controls, which did not undergo root canal obturation. The root canals were then dried with standardized sterile paper cones; conometry was performed with a gutta-percha cone number 45.02, tested and adjusted to the working length.

The obturation of canals was performed with the lateral compaction technique using standardized gutta percha and the respective ES. The application of the ES in the root canal was performed with the same chosen gutta-percha master cone number 45.02. For the lateral compaction, a digital spacer size B (Maillefer-Dentsply) was used entering 1-2 mm short of the working length, and accessory gutta-percha cones number 20.02 were used. Excess gutta-percha was removed using a hot instrument and the corresponding vertical compaction was performed; the coronal part of the canal was sealed with Coltosol® F cement to an average depth of 4 mm.

Each specimen was placed in a respective test tube, previously coded by each ES group containing saline solution. They were then placed in an incubator at the microbiology laboratory of the Universidad Peruana Cayetano Heredia (UPCH) for two weeks at 37 °C and 100% humidity for complete setting of the ES (10, 12, 14, 15).

Subsequently, specimens were cut transversely at 3 mm and 7 mm of the root apex with a carborundum (dentorium) disk, with constant water cooling to 5 °C, to avoid frictional heat (10). To remove all inorganic debris produced during cutting, all samples were cleaned with a 17% EDTA bath for two minutes and then with 3% NaOCl, for two minutes as well (11, 15). The specimens were left at room temperature to allow drying for 12 hours.

Sample processing

This was carried out in the specialized postgraduate equipment laboratory of the Faculty of Biological Sciences at Universidad Nacional Mayor de San Marcos (FCB-UNMSM). The specimens were taken to complete the drying process for 1 hour (Beltec Scientific PH - 050A). Afterwards, they were placed in discs duly coded for each group of ES, and then taken to the vacuum machine (SPI® - module Sputter Coater) for their respective gold coating for 4 minutes, ready for observation and measurement in the scanning electron microscope (SEM) (Inspect S50, FEI brand) (Figure 1). The measurement was performed by a professional expert in the use of the scanning electron microscope software of the same specialized postgraduate equipment laboratory of the FCB-UNMSM, thus allowing the obtaining of correct data.

The canal wall was located at a magnification of 1000x and the depth of the greatest entry of the ES into the dentinal tubules was measured at 1500x, having two reference points (the root canal wall and the most distant entry in the direction of the external root surface). This depth was measured linearly and expressed in micrometers, using the measurement tool of the XT Microscope Control software. The corresponding microphotography was taken at 1500x for its measurement (Figure 1).

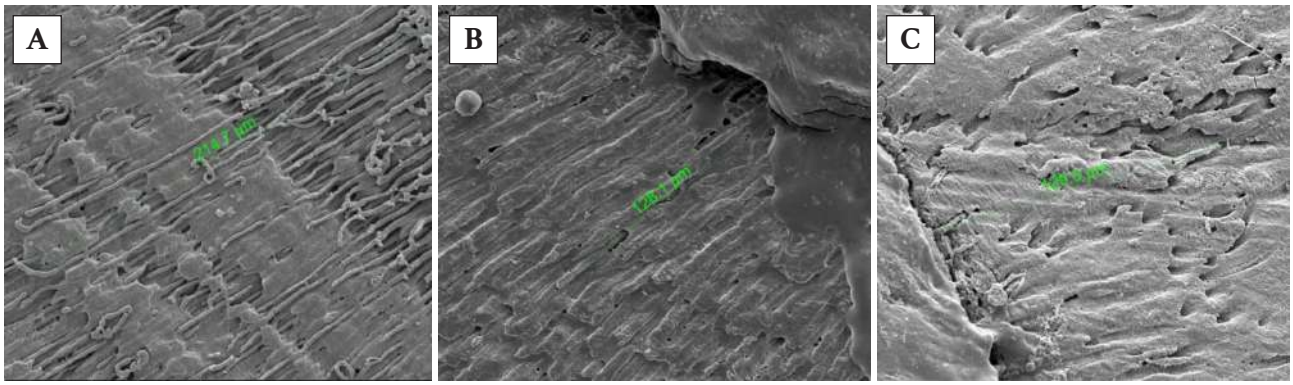

Figure 1. Penetration of the endodontic sealer into the dentinal tubules as seen under the scanning electron microscope. A) AH Plus® Sealer; B) Roekoseal® Sealer; C) Apexit Plus® Sealer.

Stata v. 11 software was used for a statistical analysis. Descriptive statistics were performed to determine the mean and standard deviation values of the penetration of each of the ES into the dentinal tubules. The assumptions of normality and homogeneity of variances of the dependent variable were analyzed. The p-value was set at 0.05. An ANOVA test was used to compare all sealer groups, and a Student's t-test was used to determine if there was a statistically significant difference when evaluating the penetration of each sealer at 3 mm and 7 mm. Tukey's post hoc test was also performed between sealant groups.

The project was implemented with the approval of the Institutional Ethics Committee of the Universidad Peruana Cayetano Heredia (CIE-UPCH) on June 9, 2017, and SIDISI code no. 100983.

RESULTS

When analyzing the three ES, at 3 mm it was found that AH Plus® sealer obtained a mean of 127.14 ± 54.55; Roekoseal®, a mean of 179.22 ± 43.71; and Apexit Plus®, a mean of 132.61 ± 59.24. And at 7 mm, it was observed that ES AH Plus® obtained a mean of 173.05 ± 48.37; Roekoseal®, a mean of 186.28 ± 71.8; and Apexit Plus®, a mean of 155.40 ± 60.29 (Table 1).

Table 1. Comparison of the penetration (μm) of three endodontic sealers into dentinal tubules with scanning electron microscopy.

Sealer	At 3 mm		At 7 mm		p[b]
	Mean	SD	Mean	SD	
AH Plus	127.14	54.55	173.05	48.37	0.040*
Roekoseal®	179.22	43.71	186.28	71.80	0.774
Apexit Plus®	132.61	59.24	155.40	60.29	0.360
p[a]	0.041*		0.468		

[a] Statistical significance of ANOVA test.
[b] Statistical significance of Student's t test.
* Statistically significant ($p < 0.05$); ANOVA test ($p = 0.04$).

Comparing the three ES, significant differences were only found at 3 mm ($p = 0.04$), with Roekoseal® ES obtaining the highest values. When each of the sealers was evaluated separately, it was observed that ES AH Plus® showed greater penetration at 7 mm than at 3 mm. This difference was statistically significant ($p = 0.04$). When the sealant groups were analyzed in pairs, no significant differences were found.

DISCUSSION

The scanning electron microscopy method was used for this study because it is one of the main and reliable

instruments that could best describe the image of the ES on the tooth surface *in vitro* (11, 16, 17), which, in turn, makes it possible to visualize images with a 3D effect, take microphotographs at high magnifications ranging from 3x to 150,000x, and observe the samples in longitudinal or transverse sections. This evaluation was performed with transverse sections at 3 mm and 7 mm from the root apex (11, 18).

Mamootil and Messer (19), Okşan et al. (20) and Bernardes et al. (21) state that a variety of factors, such as removal of the mud layer, dentin permeability (number and diameter of dentinal tubules), canal dimension, and the impact of physical and chemical characteristics of the ES, such as fluidity, affect the depth at which ES penetrate the dentinal tubules.

Zhou et al. (22) evaluated different ES: silicone-based, epoxy resin-based, mineral trioxide aggregate (MTA), zinc oxide-eugenol and bioceramic, and found greater flowability in the silicone-based ES, with statistically significant differences. Ordinola-Zapata et al. (10) evaluated the depth of penetration in the dentinal tubules of the following ES: silicone-based, calcium hydroxide-based and resin-based, obtaining results with no significant differences when comparing silicone-based ES and resin-based ES (10).

Cobankara et al. (23) observed the penetration and sealing ability of four ES: AH Plus® based resin, silicone-based Roekoseal®, glass ionomer-based Ketac Endo and zinc oxide-eugenol-based Sultan, using the lateral compaction technique; after 21 days of obturation, they observed better results for Roekoseal®, followed by AH Plus®, Ketac Endo and Sultan, with the latter showing less sealing and greater filtration in each of the samples.

In this study, the polydimethylsiloxane silicone-based Roekoseal® ES showed greater penetration into the dentinal tubules. Conversely, Balguerie et al. (11) obtained unfavorable results for Roekoseal®. This may be related to the hot gutta-percha filling technique used in that study. The manufacturer of Roekoseal® states that with heat sealing techniques, the working time is reduced (24). An increase in temperature could explain the lower penetration of ES at the level of the dentinal tubules and present a granular appearance in the scanning electron microscope. In our study, the manufacturer›s recommendations were followed, which is to use Roekoseal® in cold gutta-percha filling technique. The greater penetration into the dentinal tubules may be due to the high fluidity of Roekoseal®, as mentioned by other authors and the manufacturer (24, 25).

Faira-Júnior et al. (26) evaluated the flowability of five ES, having as a result that the calcium hydroxide-based ES showed higher flowability compared to the epoxy resin-based ES. The author mentions that it could be because the formula of the epoxy resin sealer was modified in its composition by the manufacturers, substituting methamine with TCD-diamine. In this study, the AH Plus® epoxy resin-based ES showed greater penetration into the dentinal tubules compared to Apexit Plus®, which is a calcium hydroxide-based ES. Most importantly, although ES AH Plus® showed a lower penetration at 3 mm from the root apex, it had a notable improvement at 7 mm. Bernardes et al. (21) evaluated the flowability of three ES (Sealer 26, AH Plus® and MTA Obtura), reporting a higher flowability for the AH Plus® ES, which could be due to the concentration of epoxy resin it contains, unlike the other ES used (21).

Chandra et al. (27) showed that there was no significant difference in the depth of penetration in the apical third between RoekoSeal® and AH Plus® ES. In this study, a lower penetration was found for the three ES evaluated at the apical 3 mm, which is like the studies of Balguerie et al. (11), Bassem et al. (15), Teixeira et al. (28) and Paqué et al. (29), who agree that the poorest penetration of sealers into the dentinal tubules occurs in the apical third. This can be explained by the inefficient entry of irrigant into this region of the root canal, by the reduced diameter and number of dentinal tubules in this area, and by the greater presence of tubular sclerosis.

Siqueira et al. (14) evaluated the flowability and antibacterial effect of several ES, such as Kerr Pulp Canal Sealer™ EWT, Grossman®, ThermaSeal, Sealer 26 and AH Plus®, and found that AH Plus® and Kerr Pulp Canal Sealer™ have superior flowability values, and that all of them showed some antimicrobial activity, thus suggesting that these ES have potential to aid in the microbial control of the root canal system (14). Kwak et al. (30) also report that ES neutralize the nutrient pathway of microorganisms, and that they can exert an effect against residual bacteria in the dentinal tubules, thus preventing bacterial reinfection and isolation of residual stimuli in the root canal.

Versiani et al. (31) report that the penetration capacity of ES increases when the smear layer is previously removed. Kokkas et al. (12) evaluated the influence of the smear layer on the penetration of ES into the dentinal tubules, using AH Plus®, Apexit Plus® and Roth 811, obtaining favorable results for AH Plus® and Apexit Plus®. This study followed the same final

irrigation protocol for the removal of the smear layer used by Kokkas et al. (12) to favor the penetration of the ES used.

One of the limitations of the study could be the standardization of the samples with respect to the age of patients at the time the extractions were performed, since they could have differences in the size and density of the dentinal tubules.

The penetration of ES into the dentinal tubules provides positive effects in our root canal treatment, such as a larger contact surface between dentin and ES, micromechanical retentions, a hermetic seal that prevents any bacterial filtration, as it achieves a blockage of residual microorganisms in the dentinal tubules.

CONCLUSIONS

All three ES studied showed penetration into the dentinal tubules. The ES that showed the best penetration was Roekoseal®, with the best result at 3 mm.

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Comparison of hyaluronic acid and bee honey on healing and bacterial growth in guinea pig mucosa: *in vivo* study

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ABSTRACT

Objective: To compare *in vivo* the topical application of hyaluronic acid and bee honey on healing and bacterial growth in the mucosa of guinea pigs. **Materials and methods**: *In vivo* study, applied to a sample of 30 guinea pigs, classified in three groups (A, B and C), all with the same conditions (place, feeding and temperature). During five consecutive days, both in the morning and in the afternoon, the following treatments were applied topically: Hyaluronic acid in group A, bee honey in group B, and in group C (control group) no substances were applied. This was carried out using a hypodermic syringe. After sedation, a 4-mm circular incision was made in the guinea pig mucosa in the left infero-lateral region of the incisors. The following characteristics were identified at the wound site: bleeding, edema, erythema (4, 6 and 8 days), scar tissue and presence of suppuration (8 days), and bacterial culture (to measure colony forming units [CFU]). **Results:** The group to which hyaluronic acid was applied in the evolution of the wound showed a decrease in bleeding, edema and erythema; in addition, the formation of scar tissue of 4 mm on the sixth day was 60.00% (n = 6), there was epithelial union of 80.00% (n = 8) on the eighth day and showed lower CFU in the analysis ranges. **Conclusion:** Topical application of hyaluronic acid contributes to scar tissue formation, wound closure and decreased bacterial formation.

Keywords: healing; hyaluronic acid; honey; edema; erythema; suppuration.

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INTRODUCTION

Hyaluronic acid (HA) is a chemical substance in the vitreous gelatin of cow`s eyes. It is considered a high molecular weight polysaccharide, which is found in the extracellular matrix of connective tissue, synovial fluid, and it is present in high concentrations in the periodontium, gingiva and periodontal ligament (1, 2). In the field of dentistry, HA has shown antibacterial and anti-inflammatory effects during the healing process of periodontal lesions (1).

Different studies have proven the bacteriostatic action of HA. In the literature review conducted by Dahiya and Kamal (1), the study by Pirnazar et al. is mentioned, whose objective was to determine whether, depending on the concentration or molecular weight of HA, it had bactericidal or bacteriostatic effects on the growth of certain oral and non-oral strains in different species, namely: *S. mutans*, *P. gingivalis*, *Prevotella oris*, *Actinobacillus actinomycetemcomitans*, *S. aureus* and *Propionibacterium acnes*. In their results they mention that there was no bactericidal effect on any strain, regardless of the concentration or molecular weight of the HA used; however, there were notable bacteriostatic effects on growth in some of them, with a different pattern according to each strain. They mention that on *S. mutans* and *P. gingivalis* the effect was minor, while, regardless of HA concentration or molecular weight, *S. aureus* and *A. actinomycetemcomitas* showed more significant bacteriostatic effects. This could indicate that the use of HA during surgical interventions may reduce the risk of infection due to a decrease in bacterial contamination. The defense mechanism can be attributed to special characteristics, such as being viscoelastic and hygroscopic; these properties modify the environment and thus increase the consistency of the active component and serve as a barrier to prevent the passage of bacteria into tissues, including periodontal tissue (1, 2).

On the other hand, the first evidence of honey consumption dates back to the Mesolithic period (6000 years B. C.), while its use as a medicine began to be applied by the Mesopotamians 2500 B. C.; in addition, the ancient Egyptians, Greeks, Romans, among others, used honey to heal wounds (3, 4). Bee honey can be defined as a sweet-tasting, unfermented substance made by bees that has been used since ancient times, either as a food and/or medicinal product (3). Hippocrates, in his work Considerations on the treatment of wounds, mentions that honey can be used for healing (3-5). Bee honey was rediscovered in the Modern Age as an alternative antibacterial treatment against microorganisms present in wounds that are resistant to antibiotics (3-6). This is why many studies aim to demonstrate the properties of honey that help in the repair of wounds of various etiologies (4); in addition, it is considered a natural alternative treatment that reduces the cost of modern treatments, and it is easily accessible (3).

The mechanism of action occurs due to the antioxidants in honey, which scavenge free radicals as a product of the inflammatory stage, reduce oxidative stress and, in turn, the inflammatory process. At the same time, honey decreases the levels of prostaglandins, which is a substance that favors inflammation. Additionally, by eliminating bacteria that could stimulate the inflammatory response, it reduces this reaction (3, 4). The healing effect of honey may be the result of a combination of factors, such as the formation of an environment with humid characteristics to favor cellular increase, the elimination of devitalized tissue with necrotic areas, the reduction of edema, the formation of granulation tissue and its consequent epithelization, and antibacterial and fungicidal properties. In addition, its acidity increases blood oxygenation, which helps to repair tissues (3, 4).

Bee honey has antibacterial properties due to the presence of some substances such as natural acidity, phenolic compounds and hydrogen peroxide. These components help inhibit the growth of bacteria, which contributes to its ability to fight infection and promote wound healing. Bee honey has traditionally been used for medicinal purposes due to its antibacterial properties (3, 4).

The guinea pig, also known as *conejillo de Indias* or *cuy*, native to South America, shares some similar characteristics with the human gum, and being extremely docile, it is ideal for laboratory animals (7, 8).

The aim of this *in vivo* study was to compare the topical application of HA and honey on healing and bacterial growth in guinea pig mucosa.

MATERIALS AND METHODS

This investigation is an *in vivo*, single-blind, comparative and longitudinal study. The data from the experimental work were analyzed in the statistical package IBM® SPSS v. 25. A descriptive statistical analysis was performed using the software. The Kolmogorov-Smirnov normality test was applied to determine whether the variables are parametric or nonparametric. The chi-square test and ANOVA for independent samples were applied, at a significance

level of less than 0.05, which demonstrates statistical significance in relation to the substances used and clinical characteristics of the wound.

The sample was selected based on the 3Rs of animal experimentation (replace, reduce and refine). The sample consisted of 30 guinea pigs, all in the same conditions (place, feeding and temperature), with physiological similarities in terms of the formation and constitution of the buccal mucosa. Study groups of 10 guinea pigs each were formed: two groups for the application of substances (A: hyaluronic acid; B: bee honey) and a control group (C: physiological healing), considering the inclusion criteria (healthy males of the same genetic line and type, weighing 900-1,000 g, 3 to 4 months of age, with balanced feeding). Sick or injured guinea pigs were excluded.

The guinea pigs were acquired at the biotherium of the Universidad Central del Ecuador. Apart from that, they were evaluated by the veterinarian in charge of the Biology Center to identify the presence or absence of diseases and to select them according to the inclusion criteria.

Regarding the substances, the HA (Revanesse Pure®) was purchased from Medsurgical Ecuador, an authorized distribution center. Manufacturer: Prollenium Medical Technologies Inc. is a substance manufactured according to a complete series of tests in accordance with ISO 10993, lot: 18J042-15-1. Presentation: 14 mg/mL with 1 mL syringe with 30G needle, a non-cross-linked substance. Date of issue: August-2019; date of expiration: August-2020.

Honey (*Apis mellifera*) was purchased from Camari (Agricultural and Artisanal Center), accredited by the Ecuadorian Quality Management System ISO 9001-2018. Manufacturer: Pacha beekeeping association, lot: 06052019. Presentation: pure bee honey of 500 g, which complies with the Ecuadorian Technical Standard NTE INEN 1572. The bee honey used in the study complies with physical, chemical and microbiological requirements that ensure to a microbiological and food analysis carried out at the Faculty of Chemical Sciences of Universidad Central del Ecuador. It is a viscous substance. Date of issue: June-2019; expiration date: June-2020.

The adaptation phase began with a gradual change of feeding for 10 days. On day 11 of the stay in the biotherium, the veterinarian verified the conditions and weight of the guinea pigs. To determine the anesthetic dose, parenteral intramuscular ketamine was used for conscious sedation with a 1 cc syringe at a dose of 0.1 mg/kg body weight, plus atropine sulfate at a dose of 0.04 mg/kg body weight (Ket-A-Xyl®). Then, topical anesthesia (lidocaine 10% spray) was applied, and a 4-mm circular incision was made in the mandibular region on the left side lateral to the teeth with circular scalpel no. 4, posterior to the incision. Right after that, a drop of HA was applied, using a 1 cc syringe with a 30G needle, in group A (Figure 1A), while in group B bee honey was administered by means of a 10 mL syringe with the needle cut at the pivot level (Figure 1B). Group C, which served as the control group, did not receive any substance. After the procedure, the guinea pigs were placed in thermal blankets inside cages, with appropriate temperature for their recovery.

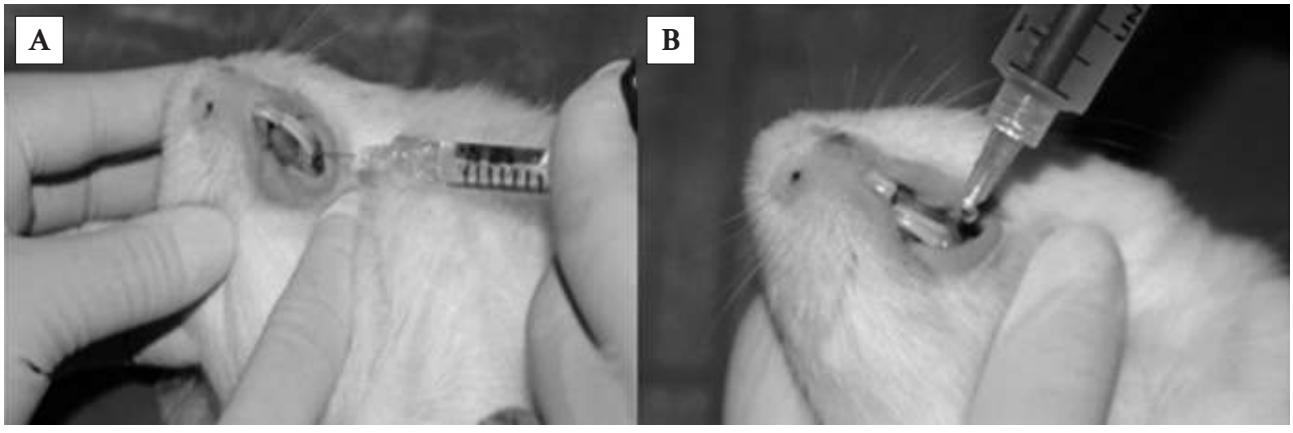

Figure 1. Immediate topical application of hyaluronic acid (A) and honey (B).

On the fourth and sixth day after incision, clinical examination of the wound was performed in the three groups to evaluate its characteristics: bleeding, edema and erythema. In addition, the amount of existing scar tissue was assessed using a Williams periodontal probe (Figure 2). For the evaluation of the scar tissue size, measurements

were taken from 0 to 4 mm. A mathematical calculation was performed considering that 4 mm is 100.00% of the healed surface. Therefore, among the results of the measurement are reference percentage values: 4 mm = 100.00%; 3 mm = 75.00%; 2 mm = 50.00%; 1 mm = 25.00%; 0 mm = 0.00% of healed surface.

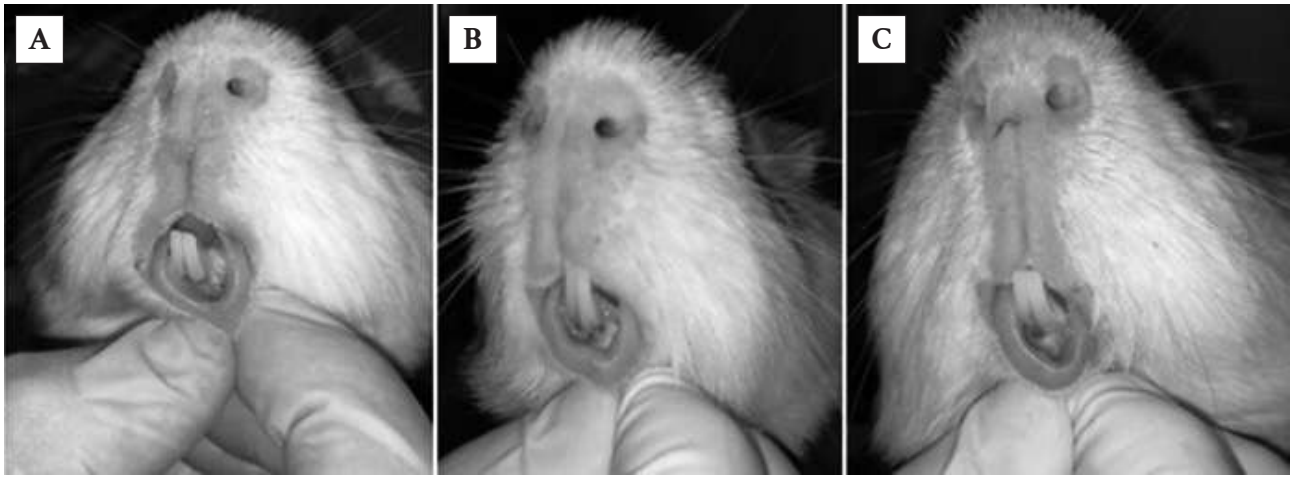

Figure 2. Wound characteristics on the fourth day. A) Hyaluronic acid; B) Bee honey; C) Control group.

On the fifth day after the incision, the wound was swabbed for bacterial culture in the three study groups. 24 hours after seeding, the Petri dishes were removed from the incubator to count the colony forming units (CFU) of the three study groups (Figure 3). On the eighth day after incision, clinical examination of the wound was performed in all three groups to evaluate wound characteristics: bleeding, edema, erythema, suppuration and epithelial junction.

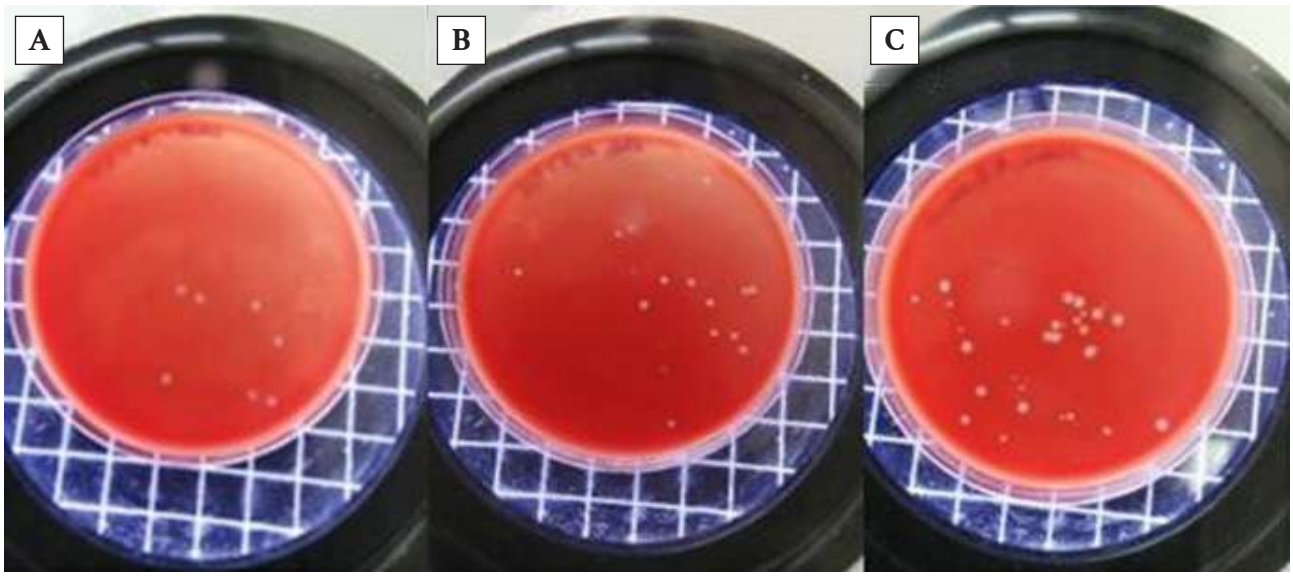

Figure 3. CFU count of two Petri dishes for each sample of hyaluronic acid group (A), honey bee group (B) and control group (C).

Dichotomous data were used for the quantification of the dependent variables of the study, which correspond to the wound characteristics mentioned previously, by observation and palpation. They were categorized according to the absence or presence of the clinical feature.

This research had the approval of the Ethics Committee of the Universidad Central del Ecuador, on November 26, 2019.

RESULTS

The total sample included in the study was 30 guinea pigs, divided into three groups of 10 (33.33%; n = 10): A (hyaluronic acid [HA]); B (bee honey); C (control group). All guinea pigs were kept in the same conditions and mucosal substances were applied to compare healing and bacterial growth.

On the fourth day, group A (HA) presented bleeding in 16.67% (n = 5) of the cases; group B (bee honey) in 23.33% (n = 7); and group C (control group) in 23.33% (n = 7). Both erythema and edema were present in 100.00% (n = 30) of cases in all three groups.

On the sixth day, group A (HA) showed bleeding in 13.33% (n = 4) of the cases; group B (bee honey) in 16.67% (n = 5); while in group C (control group) it occurred in 23.33% (n = 7). As for erythema, group A (HA) evidenced it in 13.33% (n = 4) of the cases, group B (bee honey) in 16.67% (n = 5), and group C (control group) in 23.33% (n = 7). Regarding edema, group A (HA) presented it in 3.33% (n = 1) of the cases, group B (bee honey) in 10.00% (n = 3), and group C (control group) in 16.67% (n = 5).

On the eighth day, group A (HA) presented bleeding in 6.67% (n = 2), group B (bee honey) in 10.00% (n = 3), and group C (control group) in 20.00% (n = 6). Regarding erythema, group A (HA) showed it in 10.00% (n = 3), group B (bee honey) in 13.33% (n = 4), and group C (control group) in 16.67% (n = 5). Regarding edema, group A (HA) presented it in 3.33% (n = 1), group B (bee honey) in 6.67% (n = 2), and group C (control group) in 10.00% (n = 3). The data indicate that HA contributes to a decrease in clinical wound characteristics compared to the use of bee honey and physiological healing (Table 1).

Table 1. Comparison and evaluation of the clinical characteristics of the wound between days 4-8 (day 6: measurement of scar tissue; day 8: presence of purulent discharge and epithelial junction).

Clinical features	Substances												Total	
	Hyaluronic acid (A)				Bee honey (B)				Control group (C)					
	Yes		No		Yes		No		Yes		No			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Bleeding														
Day 4	5	16.67	5	16.67	7	23.33	3	10.00	7	23.33	3	10.00	30	100.00
Day 6	4	13.33	6	20.00	5	16.67	5	16.67	7	23.33	3	10.00	30	100.00
Day 8	2	6.67	8	26.67	3	10.00	7	23.33	6	20.00	4	13.33	30	100.00
Erythema														
Day 4	10	33.33	0	0.00	10	33.33	0	0.00	10	33.33	0	0.00	30	100.00
Day 6	4	13.33	6	20.00	5	16.67	5	16.67	7	23.33	3	10.00	30	100.00
Day 8	3	10.00	7	23.33	4	13.33	6	20.00	5	16.67	5	16.67	30	100.00
Edema														
Day 4	10	33.33	0	0.00	10	33.33	0	0.00	10	33.33	0	0.00	30	100.00
Day 6	1	3.33	9	30.00	3	10.00	7	23.33	5	16.67	5	16.67	30	100.00
Day 8	1	3.33	9	30.00	2	6.67	8	26.67	3	10.00	7	23.33	30	100.00
Total	40		50		49		41		60		30		270	
													Chi-square p-value	
Purulent discharge on day 8	0	0.00	10	33.33	1	3.33	9	30.00	0	0.00	10	33.33	1	0.355
Epithelial junction on day 8	8	26.67	2	6.67	6	20.00	4	13.33	3	10.00	7	23.33	17	0.034
Total	8	2.00	12	18.00	7	5.00	13	15.00	3	7.00	17	13.00		

Table 1. (*Continuation*).

	Measurement	Occupied area (%)	Hyaluronic acid		Bee honey		Control group		Total	
			n	%	n	%	n	%	n	%
Scar tissue in day 6	0 mm	0.00	0	0.00	0	0.00	1	3.33	1	3.33
	1 mm	25.00	0	0.00	0	0.00	0	0.00	0	0.00
	2 mm	50.00	0	0.00	0	0.00	4	13.33	4	13.33
	3 mm	75.00	4	13.33	5	16.67	4	13.33	13	43.33
	4 mm	100.00	6	20.00	5	16.67	1	3.33	12	40.00
Total			10	33.33	10	33.33	10	33.33	30	100.00

In the evaluation of the scar tissue on the sixth day, it was found that 43.30% (n = 13) presented a measurement of 3 mm, equivalent to 75% of the wound covered, being predominant in group B (bee honey) with 16.67% (n = 5). Scar tissue of 4 mm, equivalent to 100.00% of the covered wound, was also observed in 40.00% (n = 12), being predominant in group A (HA) with 20.00% (n = 6). Meanwhile, group C (control group) obtained measurements ranging from 0 to 3 mm (Table 1). Therefore, topical application of HA promotes the formation of scar tissue in the wound compared to the use of honey and physiological healing.

On the eighth day, during wound evaluation, suppuration was evident in group B (bee honey) in 3.33% (n = 1) of the total sample. In relation to the epithelial junction, in group A (HA) a closed wound was observed in 27.67% (n = 8); in group B (bee honey) in 20.00% (n = 6); and in group C (control group) in 10.00% (n = 3). A p-value of 0.034 was obtained, indicating a significant association between the substances administered and epithelial junction (Table 1). Therefore, topical application of HA contributes to wound closure compared to the use of honey and physiological healing.

When the CFU count was performed for each guinea pig, it was observed that, in the range of 0.00-30.00 CFU, group A (HA) presented 26.60% (n = 8); group B (bee honey), 6.60% (n = 2); and group C (control group), 0.30% (n = 1). In the range of 30.01-60.00 CFU, group A (HA) presented 6.60% (n = 2); group B (bee honey), 19.68% (n = 6); and group C (control group), 13.32% (n = 4). In the range of 60.01-100.00 CFU, group A (HA) presented 0.00% (n = 0); group B (bee honey), 6.60% (n = 2); and group C (control group), 13.32% (n = 4). In the range of 100.01-200.00 CFU, group A (HA) presented 0.00% (n = 0); group B (bee honey), 0.00% (n = 0); and group C (control group), 6.70% (n = 1) (Table 2). The topical application of HA contributes to the decrease of CFU, presenting a lower quantity in the wound compared to the use of honey and physiological healing.

Table 2. Colony forming unit (CFU) count.

Groups/study	Colony forming units (CFU)								Total	
	0-30		30.01-60		60.01-100		100.01-200			
	n	%	n	%	n	%	n	%	n	%
Hyaluronic acid	8	26.60	2	6.60	0	0.00	0	0.00	10	33.30
Bee honey	2	6.60	6	19.98	2	6.60	0	0.00	10	33.30
Control group	1	0.30	4	13.32	4	13.32	1	6.70	10	33.30
Total	11	36.6	12	40.00	6	20	1	3.33	30	100.00

DISCUSSION

HA, being a component found in high percentage in the extracellular matrix, has the characteristic of attracting water in large quantities to the intercellular space, thus achieving a tight and gelatinous cellular junction (9). It is a substance produced by fibroblasts that can be administered exogenously, enhancing the formation of matrix and elastic fibers, contributing to collagen synthesis. Several authors have reported important properties of HA, such as angiogenesis, remodeling and tissue maintenance (1, 9-11).

Topical administration of HA has proven usefulness as adjuvant therapy in gingivitis, chronic periodontitis, oral ulcers, and in wounds during the post-surgical period, favoring tissue recovery (12, 13). Pistorius et al. (14) evaluated the efficacy of topical HA administration for the treatment of gingivitis and identified that topical application of HA-containing preparation was a potentially useful adjunct.

In the study by Park et al. (15), a better macroscopic and microscopic tissue recovery was evidenced in experimental animals using HA: evidence of abscesses, neutrophilic infiltrate and less necrosis than in the control group. Overall, immediate local application of HA to wounds significantly reduced the occurrence and duration of surgical site infection in an animal model (15-18).

In this study, in relation to the epithelial junction (measured on the sixth day centripetally with the aid of a periodontal probe), it is evident that the group to which HA was applied shows a better response with measurements of 4 mm of scar tissue in 20.00% (n = 6) of the guinea pigs, showing a more compact scar tissue. On the eighth day of the clinical analysis, the wound is closed in 8 guinea pigs (27.67%) of the group to which HA was applied. This indicates a healing activity in relation to the control group. The group to which HA was applied presented a greater number of samples in the range of 0-30 CFU, which allows us to conclude that it has antibacterial activity in relation to the control group.

Studies suggest that honey has wound repairing effects and that it helps in the healing process, not only because of its antioxidant activity, but also because of its anti-inflammatory and inflammation regulating properties, an effect that can be evidenced during the evolution of wounds (5). Ndayisaba (18) discusses the rediscovery of the reparative properties of bee honey and conducted a study on 40 patients who had wounds with various causes, as well as burns with infection. This author found the reparative effectiveness of honey in 88% of the cases.

In this study, in relation to the group to which bee honey was administered, it was evidenced that, on the fourth day after the incision, there was the presence of bleeding in 23.33% (n = 7) of guinea pigs, besides erythema and edema in all guinea pigs 100.00% (n = 30). On the sixth day after the incision, bleeding and erythema were observed in 16.67% (n = 5) and edema in 10.00% (n = 3). On the eighth day, the presence of bleeding was 10.00% (n = 3), erythema in 13.33% (n = 4) and edema in 6.67% (n = 2). Apart from that, one (3.33%) guinea pig presented purulent discharge.

On the sixth day in the centripetal wound measurement, group A (HA) evidences a better response with measurements of 4 mm of scar tissue in 16.67% (n = 5) of guinea pigs, showing a thin granulation tissue.

On the eighth day of clinical analysis, the wound is closed in 6 guinea pigs, corresponding to 20.00% of the group to which honey was applied. This indicates that it has a healing activity in relation to the control group.

The group to which bee honey was applied presented a greater quantity of samples in the range 30.01-60 CFU, which allows us to conclude that it has antibacterial activity in relation to the control group.

During the study, we saw some limitations that are related to the difficulty in handling and sudden changes in the environment, which affect the behavior and health of the research subjects, as well as feeding, which can cause possible injuries during chewing and aggressive habits of guinea pigs.

CONCLUSION

Topical application of HA contributes to the formation of 4-mm scar tissue (day 6: 20.00%; n = 6), wound closure (day 8: 27.67%; n = 8) and decreased bacterial formation (range 0.00-30.00 CFU; 26.60%; n = 8), compared to topical use of honey bee and physiological healing. There is a statistically significant association between the substances administered and epithelial junction.

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Factors associated with the impact of oral health-related quality of life in employees of a Peruvian university

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ABSTRACT

Objective: To identify factors associated with the impact of oral health-related quality of life in the staff of a Peruvian university during 2023. **Materials and methods:** Cross-sectional and analytical study with 319 employees. The OHIP-14sp questionnaire was applied to evaluate oral health-related quality of life, and data were collected on different sociodemographic variables, healthy habits and use of odontological services. Bivariate and multivariate analysis was performed by means of the chi-square test and Poisson log-linear regression with robust variance, respectively. **Results:** A total of 56.74% (n = 181) of the employees presented a lower impact on oral health-related quality of life. In addition, significant associations ($p < 0.05$) were found with sex, education level and reason for consulting a dentist. Multivariate analysis showed that participants with higher university education had a greater negative impact compared to those with a PhD (aPR = 1.16; 95% CI: 1.04-1.28; p = 0.006). In addition, those who consulted for pain had a greater negative impact, in contrast to those who sought dental care for other reasons (aPR = 1.11; 95% CI: 1.02-1.22; p = 0.023). **Conclusion:** The level of education and the reason for consulting a dentist are associated with the impact on oral health-related quality of life in employees of a Peruvian university in 2023.

Keywords: quality of life; healthy lifestyle; dental care; oral health; sociodemographic factors.

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INTRODUCTION

Oral health plays an essential role in people's quality of life and is influenced by various social and health factors (1, 2). In the Peruvian context, this issue has been traditionally neglected, starting, for example, from a deficient use of dental services and the lack of resources that hinders access to the required care, in addition to a resistance to opt for good oral habits (3). The COVID-19 pandemic has exacerbated this situation by further decreasing the availability of health services. In addition, sociodemographic factors, such as educational level, gender and age, have a significant impact on oral health and associated quality of life (4, 5).

The term "oral health-related quality of life" (OHRQoL) refers to the assessment of the impact of oral health conditions on the overall well-being and satisfaction of individuals, encompassing functional, psychological and social aspects, and experiences of discomfort or pain associated with oral diseases and conditions. To assess this relationship, various instruments are used to understand how oral health affects people's ability to lead full and satisfying lives (6). Evidence based on the conduct of these studies is essential to guide public health policies that address the needs of the population and promote better access to dental care (7, 8). Ultimately, the contribution of this type of research would enable policy makers to improve the oral health and quality of life of the Peruvian population, ensuring that everyone can access the services necessary to maintain optimal oral health (9).

Findings related to this issue are expected not only to serve as a reference for future research, but also to inform public health policies and practices that address underlying social determinants and reduce disparities in oral health. In this sense, the main objective of this research was to identify the factors that were found to be associated with the impact on OHRQoL in employees of a Peruvian university in 2023.

MATERIALS AND METHODS

The study was a cross-sectional, analytical design. The target population consisted of 1886 employees of Universidad Nacional de Trujillo (UNT) in Peru, of whom 1034 were professors and 852 were part of the administrative staff. A sample of 319 workers was calculated using the method of estimating proportions in finite populations, with a maximum prevalence of 50%, a confidence interval of 95%, and a margin of error of 5%. The sample was proportionally stratified according to the occupational group of the target population (professors or administrative staff). The sampling was non-probabilistic, for which the first 175 professors and 144 administrative staff who agreed to participate in this research and who met the criteria for the selection of the sample were selected: that they could understand and complete the survey and that they gave their consent to participate.

The dependent variable in this research was the OHRQoL, evaluated by means of the OHIP-14sp survey, validated nationally and internationally and that in Peru presents a significant construct validity and discriminant validity, in addition to a global internal consistency by means of Cronbach's alpha coefficient of 0.95 and values ranging from 0.66 to 0.88. This tool is organized in 7 dimensions with 2 questions each (10, 11). The answers could be "never", "almost never", "occasionally", "frequently", and "very frequently". The independent variables included sex (male or female), age (18-29 years, 30-59 years, 60 and over), occupational group (professors or administrative staff), type of contract (appointed or contracted), level of education (high school, higher technical, higher university, master's, doctor's degree), monthly remuneration (less than 1,025 soles, between 1,025 and 2,000 soles, more than 2,000 soles), frequency of dental visits (less than once a year, once a year, more than once a year), service visited when going to the dentist (public or private), reason for consulting the dentist (routine, pain, other causes other than pain and/or routine) and frequency of daily brushing (once a day, twice a day, three or more times a day).

The OHIP-14sp questionnaire was adapted to a virtual format using Google Forms, which allows data collection automatically once it is answered by participants. This questionnaire was sent through the institutional e-mails of all teaching and administrative workers, which were provided by the Human Resources unit of the university, which, in turn, gave authorization for the study to be carried out. To find the impact of OHRQoL, questionnaire responses were dichotomized, assigning a score of 0 to those who indicated having no oral health-related problems ("never") and a score of 1 to those who reported having some problem ("almost never", "occasionally", "frequently" or "very frequently"). The scores were then summed by dimension and overall, and categorized by quartiles. Those with scores below the last quartile were considered "low impact", which means having a lower negative impact on OHRQoL.

On the other hand, scores within the last quartile or higher were classified as "high impact", which means having a higher negative impact on OHRQoL. The data were processed, and descriptive and inferential statistics were performed, including bivariate chi-square analysis and Poisson regression with robust variance to determine the adjusted prevalence ratio (aPR) of significant variables ($p < 0.05$). This research had a 95% confidence level, and the IBM SPSS v. 25.0 software was used to perform the respective analyses.

The privacy of the participants was protected by means of a virtual informed consent, developed in accordance with international guidelines (12). In addition, the research was approved by the Ethics Committee of Universidad Peruana Cayetano Heredia under code SIDISI 210005, and permission was obtained from the Human Resources area of the UNT to carry out the research. It is important to emphasize that all procedures were carried out following ethical standards and guaranteeing the confidentiality of the data according to the guidelines of the Helsinki declaration (13).

RESULTS

The results showed that 52.35% (n = 167) of participants were women and 67.71% (n = 216) were in the age range of 30 to 59 years. The majority were professors, with 54.86% (n = 175), being mostly staff appointed with 71.16% (n = 227). A high educational level stood out, with 31.66% (n = 101) having reached the master's degree level; and 61.44% (n = 196) had a monthly remuneration higher than 2000 soles. Regarding oral health habits, 45.14% (n = 144) visited the dentist at least once a year; 88.09% (n = 281) visited a private dentist; and "other causes" was the main reason for consultation, with 41.07% (n = 131). Regarding brushing, 42.63% (n = 136) brushed twice a day, while 46.08% (n = 147) brushed three or more times a day (Table 1).

Regarding the OHIP-14sp questionnaire, we should mention that the dimension "psychological discomfort" was the one with the most "frequent" responses, with 30.72% (n = 98) of participants expressing concern about oral problems. Overall, the dimensions showed a high frequency of responses in the "never" and "almost never" categories; however, a significant percentage of "occasionally" responses was observed, ranging from 10.97% (n = 35) to 40.75% (n = 130). Dimensions such as physical pain, physical disability and psychological discomfort were notable for having a significant number of occasionally" responses (Table 2).

Table 1. Sociodemographic characteristics of workers of the Universidad Nacional de Trujillo.

Variable	n	%
Sex		
Female	167	52.35
Male	152	47.65
Age		
18 to 29 years	10	3.13
30 to 59 years	216	67.71
60 to more years	93	29.15
Occupational group		
Administrative Staff	144	45.14
Professor	175	54.86
Type of contract		
Contracted	92	28.84
Appointed	227	71.16
Level of education		
High school	8	2.51
Higher technical	46	14.42
Higher university	64	20.06
Master's degree	101	31.66
Doctor's degree	100	31.35
Monthly remuneration		
Less than 1025 soles	24	7.52
Between 1025 and 2000 soles	99	31.03
Greater than 2000 soles	196	61.44
Frequency of visits to the dentist		
Less than once a year	103	32.29
Once a year	144	45.14
More than once a year	72	22.57
Type of service you visit when you visit the dentist		
Private	281	88.09
Public	38	11.91
Reason for going to the dentist		
Routine	106	33.23
Pain	82	25.71
Other causes	131	41.07
Daily brushing frequency		
Once a day	36	11.29
Twice a day	136	42.63
Three or more times a day	147	46.08

Table 2. Oral health impact profile of workers of Universidad Nacional de Trujillo.

OHIP-14sp	Never		Almost never		Occasionally		Frequently		Very frequently	
	n	%	n	%	n	%	n	%	n	%
Functional limitation										
Have you had difficulty pronouncing words?	148	46.39	98	30.72	69	21.63	3	0.94	1	0.31
Do you feel that the taste of food has varied?	157	49.22	87	27.27	64	20.06	6	1.88	5	1.57
Physical pain										
Have you felt pain in your mouth?	89	27.90	120	37.62	104	32.60	5	1.57	1	0.31
Have you had discomfort when eating?	86	26.96	107	33.54	117	36.68	7	2.19	2	0.63
Psychological distress										
Are you worried about the problems in your mouth?	21	6.58	43	13.48	130	40.75	98	30.72	27	8.46
Have you felt stressed because of problems in your mouth?	69	21.63	101	31.66	110	34.48	28	8.78	11	3.45
Physical disability										
Have you had to change your food because of problems with your mouth?	117	36.68	107	33.54	81	25.39	9	2.82	5	1.57
Have you had to interrupt your food due to problems with your mouth?	123	38.56	104	32.60	80	25.08	8	2.51	4	1.25
Psychological disability										
Have you had problems sleeping because of problems in your mouth?	136	42.63	117	36.68	57	17.87	6	1.88	3	0.94
Have you been embarrassed for problems in your mouth?	122	38.24	96	30.09	74	23.20	19	5.96	8	2.51
Social disability										
Have you been irritable due to problems with your mouth?	133	41.69	98	30.72	79	24.76	6	1.88	3	0.94
Have you had difficulty to do your daily activities due to problems in your mouth?	151	47.34	103	32.29	57	17.87	6	1.88	2	0.63
Handicap										
Have you felt that life in general has been less pleasant because of problems in your mouth?	147	46.08	96	30.09	60	18.81	10	3.13	6	1.88
Have you been totally unable to do your daily activities due to problems in your mouth?	194	60.82	86	26.96	35	10.97	3	0.94	1	0.31

Regarding the impact on OHRQoL, it was observed that the areas of functional limitation, psychological disability, social disability and handicap showed mainly a lower negative impact (low impact), while physical pain, psychological discomfort and physical limitation mostly showed a higher negative impact (high impact). Despite this, in general terms, most of the participants perceived a lower negative impact on their OHRQoL, with a prevalence of 56.74% (n = 181) (Table 3).

Table 3. Impact of the OHRQoL of workers at Universidad Nacional de Trujillo.

	Low impact		High impact	
	n	%	n	%
Dimension				
Functional limitation	197	61.76	122	38.24
Physical pain	119	37.30	200	62.70
Psychological distress	69	21.63	250	78.37
Physical disability	145	45.45	174	54.55
Psychological disability	177	55.49	142	44.51
Social disability	169	52.98	150	47.02
Handicap	200	62.70	119	37.30
OHIP-14sp (total)	181	56.74	138	43.26

Through inferential analysis, significant associations were found between some of the factors included and the impact on OHRQoL. Regarding sex, women reported a lower negative impact than men (PR = 0.92; 95% CI: 0.86-0.99; p = 0,035). Regarding the level of education, workers at the higher university level (PR = 1.17; 95% CI: 1.06-1.30; p = 0.003) or master's degree (PR = 1.10; 95% CI: 1.01-1.21; p = 0.047) reported a greater negative impact than those with a PhD. Those who visited the dentist for pain reported a greater negative impact compared to those who visited the dentist for other causes (PR = 1.13; 95% CI: 1.04-1.24; p = 0,007). No significant associations were found with the other variables included in this study (Table 4).

Table 4. Bivariate analysis between sociodemographic characteristics and the impact of OHRQoL of workers at Universidad Nacional de Trujillo.

Variable	Low impact		High impact		PR	CI (95 %)	p*
	n	%	n	%			
Sex							
Female	104	57.46	63	45.65	0.92	0.86-0.99	0.035
Male	77	42.54	75	54.35	1		
Age							
18 to 29 years	4	2.21	6	4.35	1.17	0.96-1.44	0.126
30 to 59 years	118	65.19	98	71.01	1.07	0.98-1.16	0.149
60 to more years	59	32.60	34	24.64	1		
Occupational group							
Administrative Staff	80	44.20	64	46.38	1.02	0.94-1.10	0.698
Professor	101	55.80	74	53.62	1		
Type of contract							
Contracted	47	25.97	45	32.61	1.06	0.97-1.15	0.191
Appointed	134	74.03	93	67.39	1		
Level of education							
High school	3	1.66	5	3.62	1.23	0.99-1.53	0.061
Higher technical	26	14.36	20	14.49	1.09	0.96-1.23	0.179
Higher university	29	16.02	35	25.36	1.17	1.06-1.30	0.003
Master's degree	55	30.39	46	33.33	1.10	1.01-1.21	0.047
Doctor's degree	68	37.57	32	23.19	1		

Table 4. (*Continuation*).

Variable	Low impact		High impact		PR	CI (95 %)	p*
	n	%	n	%			
Monthly remuneration							
Less than 1025 soles	12	6.63	12	8.70	1.05	0.91-1.21	0.5
Between 1025 and 2000 soles	57	31.49	42	30.43	0.99	0.92-1.08	0.943
Greater than 2000 soles	112	61.88	84	60.87	1		
Frequency of visits to the dentist							
Less than once a year	59	32.60	44	31.88	0.94	0.85-1.04	0.255
Once a year	87	48.07	57	41.30	0.92	0.84-1.01	0.095
More than once a year	35	19.34	37	26.81	1		
Type of service you visit when you visit the dentist							
Private	164	90.61	117	84.78	0.91	0.82-1.02	0.101
Public	17	9.39	21	15.22	1		
Reason for going to the dentist							
Routine	71	39.23	35	25.36	0.94	0.86-1.03	0.192
Pain	33	18.23	49	35.51	1.13	1.04-1.24	0.007
Other causes	77	42.54	54	39.13	1		
Daily brushing frequency							
Once a day	18	9.94	18	13.04	1.09	0.97-1.23	0.162
Twice a day	71	39.23	65	47.10	1.08	0.99-1.17	0.076
Three or more times a day	92	50.83	55	39.86	1		
Total	181	56.74	138	43.26			

PR: prevalence ratio; CI: 95% confidence interval; p: statistical significance.
* chi-square test.

After adjusting the variables with statistical significance, through the regression models used, significant aPR were found for OHRQoL in participants with a higher university level who presented a greater negative impact with respect to those with a PhD (APR = 1.16; 95% CI: 1.04-1.28; p = 0,006). At the same time, a greater negative impact was obtained in those who went to the dentist for pain compared to those who went to the dentist for other causes (APR = 1.11; 95% CI: 1.02-1.22; p = 0.023) (Table 5).

Table 5. Poisson regression model with robust variance to evaluate the impact of OHRQoL in workers of the Universidad Nacional de Trujillo, according to sex, level of education and reason for visiting the dentist.

Variable	aPR	CI (95%)	p
Sex			
Female	0.93	0.86-1.01	0.054
Male	1		
Level of education			
High school	1.11	0.90-1.37	0.320
Higher technical	1.09	0.96-1.23	0.175
Higher university	1.16	1.04-1.28	0.006
Master's degree	1.10	0.99-1.21	0.052
Doctor's degree	1		
Reason for going to the dentist			
Routine	0.96	0.87-1.04	0.315
Pain	1.11	1.02-1.22	0.023
Other causes	1		

aPR: adjusted prevalence ratio, each variable was adjusted for the other two variables (sex, level of education, reason for dental visit); CI: 95% confidence interval; p: statistical significance.

DISCUSSION

Quality of life is a crucial indicator of health and well-being. Therefore, in the field of oral health, it refers to the way a person perceives his or her ability to do their daily activities without pain (11). Dental conditions, such as caries, periodontitis or tooth loss, have an adverse impact on quality of life (10, 13). These problems can also restrict food choice and affect overall health. Therefore, it is essential to maintain good oral hygiene to improve the level of well-being and quality of life (7, 14).

This study highlights the fact that the majority of workers were women (30-59 years old), who indicated their high concern for oral health and their related quality of life. On the other hand, professors and appointed personnel were the groups that represented a high educational level, suggesting a possible educational influence on their mouth care practices. Domínguez-Crespo et al. (5) found that many workers visit the dentist annually, preferring private services for various reasons. In this study, 45.1% visited a dentist at least once a year, while 88.1% chose private dentists. The main reason for consultation is due to other causes, indicating concern for prevention. In fact, most of them brush at least twice a day, showing an acceptable concern for their oral hygiene.

Regarding the OHIP-14sp questionnaire, psychological distress showed a greater negative impact on OHRQoL, like that observed by authors such as Domínguez-Crespo et al. (5) and Drachev et al. (15), who suggest that oral problems may derive from poor mental health. Physical pain also had a greater negative impact on OHRQoL, as mentioned by researchers such as Batista et al. (10) and Drachev et al. (15), indicating that the perception of pain may negatively influence the feeling of having good oral hygiene. In contrast, physical disability showed a greater negative impact than what was reported by Domínguez-Crespo et al. (5), Batista et al. (10) and Drachev et al. (15), who report a low influence of this dimension on the OHRQoL, which could be due to differences in the participants' appreciation of their functional capacity, possibly influenced by cultural factors and variations in the perception of pain between studies.

Bivariate analysis revealed significant associations for the variables gender, level of education and reason for consultation. However, after adjusting for these variables in the regression model, the level of education and reason for consultation showed significant associations. This is interesting because several studies have highlighted gender, especially in women, as a significant factor in OHRQoL, attributing these differences to perceptions of beauty and esthetic standards influenced by sociocultural factors. Results vary among studies and may differ from the present findings (10, 15, 16).

The level of education showed an association with the impact on their OHRQoL, suggesting that workers with higher education experienced a lower negative impact on OHRQoL. Statistical significance was observed when contrasting workers who have a PhD with workers who only have a higher level of education without having completed any postgraduate studies. Although the relationship for workers with a master's degree did not reach statistical significance, they demonstrated a predisposition to have a greater negative impact on their OHRQoL, in contrast to workers with a PhD. In this regard, Quintanilla-Cohello et al. (16) mentioned that the level of education was associated with psychological distress in Venezuelan migrants, highlighting that a high level of education can improve knowledge and perceptions about oral health prevention, thus reducing the negative impact on OHRQoL. However, the differences evidenced in

these results, in contrast to other studies, should be considered, since the sociocultural reality and the study population are different.

In the case of the reason for consultation, it is also associated with the impact on the OHRQoL, presenting a greater negative impact for those who visit the dental service because of pain, in contrast to those who visit it for other causes, which can be interpreted as reasons related to oral esthetics or discomfort with the stomatognathic system. This finding coincides with previous studies (10, 17), which also found an association between the reasons for visiting the dentist and the OHRQoL, highlighting a greater negative impact on those who visit the dentist because of pain. It is crucial to understand that tooth disease can have a significant effect on life quality and overall well-being, as one of the main reasons for seeking dental care (18).

The study has limitations, such as the following: its implementation in a single workplace could affect the generalization of results. The majority sample of appointed personnel may have generated a selection bias; data collected through a self-administered questionnaire may contain response bias; and unmeasured factors, such as previous oral health or the quality of dental services could influence the results. Nevertheless, and considering these limitations, the present research offers important and relevant information regarding the appreciation of oral health through its OHRQoL, which is useful because it could boost the design of oral health intervention proposals aimed at improving access to preventive dental care and the promotion of healthy oral hygiene habits in university workers, to reduce the gap in quality of life and promote a more equitable well-being among all workers. In the case of UNT workers, these actions could help reduce disparities in OHRQoL and improve their perception of OHRQoL. In addition, it would be beneficial to provide education and awareness about the importance of oral health and how it can affect overall well-being. Therefore, we recommend the investigation of these limitations in future studies to obtain a broader understanding of the association between factors influencing oral health and the impact on quality of life in different population groups.

CONCLUSIONS

The level of education and the reason for visiting the dentist were found to be associated with the impact of the OHRQoL of UNT workers. Workers who had a higher level of university education and who visited the dentist for pain had a greater negative impact on their OHRQoL, compared with those who had a PhD and went to the dentist for other reasons, respectively. In addition, although the overall impact is mostly low, which makes it have less of a negative effect on workers, psychological distress, physical pain and disability are dimensions that impact workers more negatively.

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Toothpaste use in children under 12 years of age in Peru during the years 2019-2021: a multivariate analysis

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ABSTRACT

Objective: To determine the use of toothpaste in Peruvian children under 12 years of age during the period 2019-2021. **Materials and methods:** Cross-sectional study where the records of the Demographic and Family Health Survey-ENDES (from 2019 to 2021) were used to collect information on oral health. The results were examined according to the study variables, and statistical analyses were performed. **Results:** A total of 98.89% (n = 81,668) of Peruvian children under 12 years of age used toothpaste in the period 2019-2021; however, its use decreased over the years, finding statistically significant differences. The use of fluoride toothpaste with a minimum of 1,000 ppm increased over the years, finding statistically significant differences. In the multivariate analysis there was a positive association between the year 2020 and the use of fluoride toothpaste with a minimum of 1,000 ppm (aPR = 1.04; 95% CI: 1.01-1.07; p = 0.004). A positive association was also found between the year 2021 and the use of fluoride toothpaste with a minimum of 1,000 ppm (aPR = 1.12; 95% CI: 1.10-1.15; p < 0.001). **Conclusions:** There is an association between the use of toothpaste and year, natural region, area of residence, place of residence, altitude and age; in addition to association between the use of fluoride toothpaste with a minimum of 1,000 ppm and year, natural region, area of residence, place of residence, wealth index and age.

Keywords: dentifrice; child; COVID-19.

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INTRODUCTION

Oral diseases constitute a considerable public health burden in many countries, and the most frequent is dental caries. It can occur throughout life. It is chronic, dynamic and multifactorial, affecting approximately 2 billion people with permanent dentition and 520 million children with deciduous dentition (1). Low- and middle-income nations mostly have a high prevalence of dental caries, mainly due to poor fluoride exposure, reduced access to oral health care services, and the affordability and availability of sugar-rich foods (2).

At the time of oral hygiene, one of the protective factors against dental caries is fluoride toothpaste or toothpaste (3), which is recommended to contain an optimal fluoride level of 1,000 to 1,500 ppm to promote remineralization and regression of the disease (4). Current evidence recommends toothbrushing with toothpaste twice a day to prevent dental caries, a result that is enhanced if supervised (5, 6). Early initiation of tooth brushing is important to reduce the development of childhood caries and should be performed as soon as the first deciduous teeth erupt (3).

In March 2020, the World Health Organization (WHO) announced the onset of the pandemic due to the emergence of SARS-CoV-2, a virus causing coronavirus 2019 (COVID-19). In the context of the health crisis, dental services were closed until May of the same year (7), probably triggering changes in access or timely treatment, in oral hygiene, and could even limit counseling on good eating habits, especially in a population as vulnerable as the pediatric one (3). During this period, proper oral health management and oral hygiene practices in this age group became crucially important (8), so we must consider possible changes before, during and after confinement.

Prior to the pandemic, the use of fluoride toothpastes was limited in low-income populations living in urban areas in several countries. In addition, parental supervision of this hygiene practice is important; however, their lack of knowledge hinders them from fulfilling this role (9-14). In some countries, the use of fluoride toothpastes is a low-cost resource (10), important for the prevention of dental caries, and its application from an early age could minimize its risk. However, its use could have been modified due to the COVID-19 pandemic. Given the limited evidence on this topic, the objective of this study was to determine the use of toothpaste in Peruvian children under 12 years of age during the period 2019-2021.

MATERIALS AND METHODS

The type of study was cross-sectional, and the population was constituted with information from the Demographic and Family Health Survey (ENDES) database prepared by the National Institute of Statistics and Informatics (INEI) of Peru, which constituted the secondary source of data with respect to the years 2019, 2020 and 2021. Only records of children under 12 years of age were considered at the national level, with the final sample size being 34,196 records for 2019, 16,813 for 2020, and 32,023 for 2021 (15-17).

This investigation included records of children under 12 years of age from the Demographic and Family Health Survey database for the years 2019, 2020 and 2021 and who used toothpaste, eliminating records that did not have complete data. The dependent variables were the use of toothpaste and the use of toothpaste with a minimum of 1,000 ppm. The independent variable was the year of application of the survey; and the covariates were the natural region of residence, area of residence, altitude of residence, place of residence, wealth indicator, possession of health insurance, age and sex.

We accessed the INEI website, we downloaded the databases, we combined (merged) them, and the incomplete records were eliminated. The information obtained was exported to Stata SE/15.1, considering a confidence level of 95% and a $p < 0.05$. Descriptive analysis and bivariate analysis were performed using the chi-square statistical test. In the multivariate analysis, Poisson logistic regression was used to obtain crude (PR) and adjusted (aPR) prevalence ratios. The covariates considered in the adjusted models were those that previously reported a bivariate association: natural region, area of residence, place of residence, wealth index, health insurance tenure, age and sex. The svy command was used to perform the calculations considering the complex sampling design to obtain representative approximations. The study was accepted and approved (August 15, 2022, with code SIDISI 209325) by the Integrated Research, Science and Technology Management Unit (UIGICT) of the Facultades de Medicina, Estomatología y Enfermería from Universidad Peruana Cayetano Heredia (UPCH), as well as by the Institutional Ethics Committee of the same university (CIE-UPCH).

RESULTS

It was observed that 98.89% (n = 81,668) of the study population used toothpaste; however, the use decreased

over the years. Therefore, in 2019, 99.01% (n = 33,585) was registered. In 2020, it was 98.93% (16,545) and in 2021 it decreased to 98.72% (n = 31,538). Statistically significant differences were found (p = 0.031). In addition, 78.79% (n = 46,913) used fluoride toothpaste with a minimum of 1,000 ppm, and its amount increased with the years, presenting 76.65% (n = 17,846), 78.55% (n = 9,517) and 81.46% (n = 19,550) in the years 2019, 2020 and 2021, respectively. Statistically significant differences were also found (p < 0.001). The sample corresponded mainly to Lima Metropolitana with 32.07% (n = 5,905); 77.38% (n = 33,037) resided in urban areas; 32.07% (n = 5,905) lived in the capital; 78.62% (n = 34,614) lived less than 2,500 meters above sea level; 22.8% (n = 12,060) belonged to the poor quintile; 76.62% (n = 67,508) had health insurance; 72.77% (n = 44,589) were male; and 60.84% (n = 39,918) were aged 6 to 11 (Table 1).

Table 1. Use of toothpaste according to characteristics of Peruvian children under 12 years of age.

Variable	Total		Use of toothpaste				p*	Use of fluoride toothpaste with a minimum 1,000 ppm				p*
			Yes		No			Yes		No		
	n	%	n	%	n	%		n	%	n	%	
Total	83,032	100.00	81,668	98.89	1,364	1.11		46,913	78.79	13,896	21.21	
Year												
2019	34,196	42.90	33,585	99.01	611	0.99		17,846	76.65	6,583	23.35	
2020	16,813	21.28	16,545	98.93	268	1.07	0.031	9,517	78.55	2,806	21.45	<0.001
2021	32,023	35.82	31,538	98.72	485	1.28		19,550	81.46	4,507	18.54	
Natural region												
Lima Metropolitana	5,905	32.07	5,828	99.38	77	0.62		3,064	75.5	1,196	24.5	
Rest of the coast	14,083	26.28	13,777	98.63	306	1.37	<0.001	8,015	78.93	2,887	21.07	<0.001
Highlands	15,716	25.85	15,369	98.37	347	1.63		7,703	78.39	2,917	21.61	
Rainforest	12,157	15.80	12,010	99.17	147	0.83		7,478	85.59	1,687	14.41	
Area of residence												
Urban	33,037	77.38	32,413	98.98	624	1.02	0.002	18,320	77.71	6,564	22.29	<0.001
Rural	14,824	22.62	14,571	98.58	253	1.42		7,940	82.88	2,123	17.12	
Place of residence												
Capital	5,905	32.07	5,828	99.38	77	0.62		3,064	75.5	1,196	24.5	
Small city	14,038	21.09	13,735	98.64	303	1.36	<0.001	7,901	78.91	2,780	21.09	<0.001
Village	13,094	24.22	12,850	98.74	244	1.26		7,355	79.38	2,588	20.62	
Countryside	14,824	22.62	14,571	98.58	253	1.42		7,940	82.88	2,123	17.12	
Altitude												
<2,500 m a. s. l.	34,614	78.62	34,033	99.03	581	0.97	<0.001	19,828	78.93	6,269	21.07	<0.001
>2,500 m a. s. l.	13,247	21.38	12,951	98.36	296	1.64		6,432	78.24	2,418	21.76	
Wealth index												
Very poor	12,422	20.33	12,209	98.62	213	1.38		6,695	83.99	1,589	16.01	
Poor	12,060	22.8	11,865	98.95	195	1.05		6,993	80.88	2,159	19.12	
Middle	9,135	21.7	8,968	99.04	167	0.96	0.114	5,136	77.21	1,876	22.79	<0.001
Rich	6,858	19.05	6,705	98.86	153	1.14		3,672	75.93	1,563	24.07	
Very rich	4,926	16.12	4,807	98.78	119	1.22		2,545	72.63	1,181	27.37	
Health insurance coverage												
Yes	67,508	76.62	66,451	98.89	1,057	1.11	0.891	38,313	79.07	11,299	20.93	0.198
No	15,524	23.38	15,217	98.88	307	1.12		8,600	77.87	2,597	22.13	

Table 1. (*Continuation*).

Variable	Total		Use of toothpaste				p*	Use of fluoride toothpaste with a minimum 1,000 ppm				p*
			Yes		No			Yes		No		
	n	%	n	%	n	%		n	%	n	%	
Sex												
Male	44,589	72.77	43,833	98.89	756	1.11	0.937	25,026	78.74	7,584	21.26	0.815
Female	38,443	27.23	37,835	98.88	608	1.12		21,887	78.95	6,312	21.05	
Age												
From 0 to 5 years	43,114	39.16	41,876	97.52	1,238	2.48	<0.001	20,317	65.81	9,919	34.19	<0.001
From 6 to 11 years	39,918	60.84	39,792	99.77	126	0.23		26,596	86.41	3,977	13.59	

* p: statistical significance.
Chi-square test.

In the bivariate analysis, an association was found between the use of toothpaste and the variables year, natural region, area of residence, place of residence, altitude and age. In addition, an association was observed between the use of fluoride toothpaste with a minimum of 1,000 ppm and the variables year, natural region, area of residence, place of residence, wealth index and age. In the multivariate analysis, there was a positive association between the year 2020 and the use of fluoride toothpaste with a minimum of 1,000 ppm, and an aPR = 1.04 (IC 95%: 1.01-1.07; p = 0.004). A positive association was also found between the year 2021 and the use of fluoride toothpaste with a minimum of 1,000 ppm, finding an aPR = 1.12 (95% CI): 1.10-1.15; p < 0.001) (Table 2).

Table 2. Association between toothpaste use and the years 2019-2021 in Peruvian children under 12 years old.

Variable	Use of toothpaste (Yes)						Use of fluoride toothpaste with a minimum of 1,000 ppm (Yes)					
	PR	95% CI	p	aPR[a]	95% CI	p	PR	95% CI	p	aPR[b]	95% CI	p
Year												
2019	Ref.			Ref.			Ref.			Ref.		
2020	0.99	0.99-1.00	0.500	0.99	0.99-1.00	0.862	1.03	0.99-1.03	0.078	1.04	1.01-1.07	0.004
2021	0.99	0.99-0.99	0.010	1.00	0.99-1.00	0.265	1.06	1.04-1.09	<0.001	1.12	1.10-1.15	<0.001
Natural region												
Lima Metropolitana	Ref.						Ref.					
Rest of the coast	0.99	0.98-0.99	<0.001	-	-	-	1.05	1.02-1.08	0.002	-	-	-
Highlands	0.98	0.98-0.99	<0.001	-	-	-	1.04	1.01-1.07	0.010	-	-	-
Rainforest	0.99	0.99-1.00	0.093	-	-	-	1.13	1.10-1.16	<0.001	-	-	-
Area of residence												
Urban	Ref.						Ref.					
Rural	0.99	0.99-0.99	0.004	-	-	-	1.07	1.05-1.09	<0.001	-	-	-
Place of residence												
Capital	Ref.						Ref.					
Small city	0.99	0.98-0.99	<0.001	-	-	-	1.05	1.02-1.08	<0.001	-	-	-
Village	0.99	0.99-0.99	<0.001	-	-	-	1.05	1.02-1.08	<0.001	-	-	-
Countryside	0.99	0.98-0.99	<0.001	-	-	-	1.10	1.07-1.13	<0.001	-	-	-

Table 2. (*Continuation*).

Variable	Use of toothpaste (Yes)						Use of fluoride toothpaste with a minimum of 1,000 ppm (Yes)					
	PR	95% CI	p	aPR[a]	95% CI	p	PR	95% CI	p	aPR[b]	95% CI	p
Altitude												
<2,500 m a. s. l.	Ref.						Ref.					
>2,500 m a. s. l.	0.99	0.99-0.99	<0.001	-	-	-	0.99	0.97-1.01	0.400	-	-	-
Wealth index												
Very poor	Ref.						Ref.					
Poor	1.01	1.01-1.01	0.035	-	-	-	0.96	0.94-0.98	0.001	-	-	-
Middle	1.01	1.01-1.01	0.012	-	-	-	0.92	0.89-0.94	<0.001	-	-	-
Rich	1.00	0.99-1.01	0.181	-	-	-	0.90	0.88-0.93	<0.001	-	-	-
Very rich	1.00	0.99-1.01	0.417	-	-	-	0.86	0.83-0.90	<0.001	-	-	-
Health insurance coverage												
Yes	Ref.						Ref.					
No	0.99	0.99-1.00	0.891	-	-	-	0.86	0.96-1.01	0.205	-	-	-
Sex												
Male	Ref.						Ref.					
Female	0.99	0.99-1.00	0.937	-	-	-	1.00	0.98-1.03	0.814	-	-	-
Age												
From 0 to 5 years	Ref.						Ref.					
From 6 to 11 years	1.02	1.02-1.03	<0.001	-	-	-	1.31	1.29-1.34	<0.001	-	-	-

PR: prevalence ratio; aPR: adjusted prevalence ratio; 95% CI: 95% confidence intervals.
[a] Adjusted by natural region, area of residence, place of residence, altitude and age.
[b] Adjusted for natural region, area of residence, place of residence, wealth index and age.

DISCUSSION

Backed by more than 70 years of research, the benefits of fluoride toothpastes are firmly established. Toothbrushing with fluoride toothpaste is one of the most effective methods in reducing carious lesions in children and adults (4) and it is one of the most important interventions in the history of oral health. It is the key element in preventing and even reversing the onset and progression of dental caries (18), as it maintains a constant low level of fluoride in the oral environment (19). Current evidence highlights the importance of fluoride concentration and its daily frequency in tooth brushing, which inhibits the demineralization process and favors enamel remineralization through the formation of fluorapatite crystals (18, 20).

This study found that the use of fluoride toothpaste with a minimum of 1,000 ppm in Peruvian children increased over the years. This could be due to the fact that toothbrushing is considered a fundamental self-care behavior for the maintenance of oral health (5), as well as oral health education as it can increase knowledge about fluoride toothpaste and, in turn, improve behavior with respect to the use of fluoride toothpastes (3, 21), and it could also be due to the change in oral health policies (6). At the same time, this study agrees with the findings of Diaz et al. (22), who observed an increase, although minimal, in the use of fluoride toothpaste with a minimum of 1,000 ppm; however, these authors carried out their research some years before the pandemic. Khan et al. (11) reported an increased use of fluoride toothpastes; however, they noted that the use of non-fluoride toothpaste remained at about one-tenth; this may be due to lack of knowledge about the benefits of fluoride. Avenetti et al. (23) found that one-third of caregivers were unsure of fluoride content, while half of them did report fluoride content; these findings could be due to conflicting messages received by families from clinical and nonclinical sources, which is compounded by the marketing of fluoride-free toothpaste claiming that it is "safe for babies." Another study in Australia reported that half of the preschool children used toothpastes with less than 1,000 ppm, one third used non-fluoride toothpaste and almost one tenth used

toothpaste with 1,000 ppm, which was associated with the higher educational level of the parents (24). In Peru, the use of fluoride toothpaste was found to increase during the year 2020 despite the increase in oral health inequalities during the pandemic (25).

According to the results obtained, the use of fluoride toothpaste in the population studied did not show statistical significance. This finding agrees with that reported by Aiuto et al. (26), who demonstrate the great variability in the use of fluoride toothpaste in different countries and population subgroups. According to these researchers, a large part of the sample was unaware of the type of toothpaste used. In the same way, the meta-analysis performed by Kumar et al. (5) indicates that it was not possible to separate the contribution of fluoride in toothpaste because none of the studies provided data to make this possible.

Geographic characteristics were significantly associated with the use of minimum 1,000 ppm paste. The rainforest was the natural region that reported using more fluoride toothpaste with a minimum of 1,000 ppm, as well as people living in rural areas or in the countryside, compared to coastal areas and departmental capitals. This could be due to the fact that the supply of toothpastes in capital cities is very diverse with different concentrations of fluoride, which leads parents to purchase toothpastes with inadequate concentrations of fluoride, since they are marketed with labels "for children" or "kids" (27). Factors such as geographic remoteness, limited exposure to fluoride, access to dental services, affordability and commercial determinants of health have been shown to play an important role in the persistence of oral health inequalities. Corporate action generally determines the availability, advertising and price of items in an attempt to influence decision making to drive consumption of certain products. There is also evidence that these practices target vulnerable populations, such as marketing to children (28-30).

Based on international experience, the Australian national survey reported that more than one-third of children living in rural and remote areas had more untreated dental caries than those living in major cities, due to a multitude of factors such as lack of water fluoridation, socioeconomic status, and shortage of dental services (20).

Sociodemographic characteristics, such as wealth index and age, had a significant association with the use of toothpaste with minimum 1,000 ppm. Most people belonging to the very poor quintile reported higher use of fluoride toothpaste with a minimum of 1,000 ppm compared to people belonging to the very rich quintile. This could be because people in the very poor quintile use a single toothpaste for all family members (26), while people in the very rich quintile purchase toothpastes differentiated according to the age of their family members, even acquiring fluoride toothpastes "for children" with less than 1,000 ppm (31, 32).

In terms of age, it was observed that more than half of the children aged 0 to 5 years did use fluoride toothpaste with a minimum of 1,000 ppm, as most children aged 6 to 11 years did. Factors such as socioeconomic status, family educational level and economic income are negatively related to the incidence of dental caries (32). Trinh et al. (33) evaluated the relationship between toothbrushing behavior and sociodemographic characteristics in Australian children. Researchers found that children who lived in high-income families, who were highly educated and who lived in households with two or more children started brushing their teeth at an earlier age.

During the development of the present study, there were limitations. Although national surveys represent important sources of information, they present biases inherent to their methodology, either during the data collection process (respondent recall and information bias) or due to the high variability of the sample size, because not all subjects had records in the study variable. Despite these limitations, this research study is the first in Peru to explore the use of toothpastes in Peruvian children under 12 years of age during the period 2019-2021, with national representativeness, using standardized questionnaires for the data collection process.

The use of toothpastes is a common hygiene practice among the population, but the importance of using fluoride toothpastes with a minimum of 1,000 ppm should be emphasized and promoted as an effective method for the prevention of dental caries. If this practice is established at an early age, it could become a lifelong habit that would help reduce the possibility of suffering dental caries; however, its use is affected by the high cost in some developing countries such as ours. Its use should be tax-exempt as a means of universal oral health prevention, as it is an undeniably effective health investment that is easy for the government to implement. If 1% is reduced in taxes, access to fluoride toothpastes will increase by approximately 1% (13, 19). Awareness of the benefits of using fluoride toothpastes

with a minimum of 1,000 ppm should be raised among all oral health stakeholders.

CONCLUSIONS

98.89% of Peruvian children under 12 years of age do incorporate toothpaste in their oral hygiene during the period 2019-2021; however, its use has decreased over the years, finding statistically significant differences. On the other hand, 78.79% used fluoride toothpaste with a minimum content of 1,000 ppm and its use increased over the years, also showing statistically significant differences. Finally, the year was positively associated with the use of toothpaste containing a minimum of 1,000 ppm fluoride, adjusted for the covariates natural region, area of residence, place of residence, wealth index and age.

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Dens invaginatus: diagnosis and clinical management. Literature review

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ABSTRACT

Dens invaginatus (DI) is a dental alteration that occurs before mineralization and is a consequence of the folding of the enamel organ within the dental papilla. Its characteristics allow the rapid onset and progression of carious lesions and, consequently, pulp and periapical disease. This article summarizes data from original articles and literature reviews from the Scopus and PubMed databases. In this sense, the aim of this literature review is to present guidelines for the clinical management of DI according to its etiology, classification and diagnosis, to improve the effectiveness of the treatment and prognosis of this very complex alteration.

Keywords: *dens in dente*; clinical diagnosis; disease management; literature review.

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INTRODUCTION

Dens invaginatus (DI) is a structural dental anomaly resulting from the folding of the external dental tissues into the pulp before the calcification process. Of still unknown etiology and with a prevalence ranging from 0.3 to 26%, the clinical characteristics of this anomaly represent a gateway for bacterial contamination and its products, causing pulpal and periapical pathology (1-6). Oehlers' classification is currently the most widely used, which indicates that invaginations can be grouped into three different types according to their radiographic presentation, from the crown to the root (1, 4, 6, 7).

The diagnosis of DI is made based on the morphology of the crown and the findings provided by complementary examinations. Two-dimensional radiographic examination is reliable for diagnosis. Currently, helical computed tomography (SCT), cone beam computed tomography (CBCT), dental operating microscope (DOM) and X-ray micro-computed tomography (micro-CT) systems are introduced to improve the accuracy in the diagnosis of DI (1, 5).

Clinical approaches to treatment vary according to the type of DI (1) and can range from preventive coronal sealing of the invagination, non-surgical endodontic treatment, apical surgery, intentional reimplantation and even exodontia of the tooth. Current technology allows us to treat a wide range of DI cases with favorable prognosis (5).

This review analyzes the concept, classification, epidemiology, etiopathogenesis, complementary examinations, diagnosis, treatment and prognosis of DI, with the aim of helping clinicians to choose the correct approach, favoring the preservation of the tooth with this anomaly.

CONCEPT

DI, also known as dens in dente, dilated compound odontoma, dents telescopes or gestational anomaly, is a malformation of tooth development resulting from the folding of the external dental tissues into the dental papilla. This alteration can occur both in the crown and on the root surface before mineralization occurs (1, 2, 6, 8).

CLASSIFICATION

The term "*dens invaginatus*" was introduced by Hallett in 1953, who also introduced the first classification, suggesting the existence of four types of invagination. In 1972, Schulze and Brand suggested twelve variations of the clinical and radiographic appearance of invagination (9, 10). Subsequently, this classification was reordered by Oehlers in 1957 and it is the one most commonly used today due to its simple nomenclature. According to Oehlers (7), there are two types of DI: *dens invaginatus coronalis* (DIC) and *dens invaginatus radicularis* (DIR). DIC is the most common and it is characterized by folding of the enamel organ into the dental papilla before mineralization occurs. According to its radiographic presentation, DIC was classified according to Oehlers as follows:

- **Type I:** Invagination is minimal and enamel-lined. It is limited only to the dental crown and does not go beyond the amelocemental junction (1, 7).
- **Type II:** The invagination is covered with enamel and goes beyond the amelocemental junction to the pulp chamber, remaining inside the root canal, but without communication with the dental pulp or the periodontal ligament (1, 7). A case of type II DIC with lateral communication with periodontal ligament has been reported (8), so an additional subcategorization of Oehlers DIC type II into three subtypes representing the extent of invagination in the coronal, middle and apical third has been proposed (9).
- **Type IIIA:** Invagination extends along the root and communicates laterally with the periodontal ligament through a pseudoforamen without pulp communication (1, 7).
- **Type IIIB:** Invagination extends along the root and communicates apically with the periodontal ligament without pulp communication (1, 7, 8, 10).

A case of type IV DI has been described in an upper lateral incisor, due to the presence of a lateral and apical invagination as in type III, which at the same time has communication with the dental pulp (8).

DIR, also known as palato-gingival groove, developmental radicular anomaly or radicular groove, is less common and is characterized by invagination of Hertwig's root sheath into the root after crown formation. There are two subtypes: in the first, invagination is lined with cementum and related to an axial radicular groove; in the second, invagination is lined with enamel within the root. Its etiology is probably due to the differentiation into ameloblasts of the epithelial cells that form part of the epithelial sheath of Hertwig. DIR can be confused radiographically with DIC type III due to the large size of the root; however, in DIC type III, both the crown

and the root are involved in the invagination, whereas in DIR only the root is involved (1).

EPIDEMIOLOGY

It was recently believed that the prevalence of DI was 0.04-10% (2). Currently, this value ranges from 0.3-26% (11, 12, 13). The prevalence of DI is significantly higher when CBCT is used for diagnosis (9-10.7%) compared to that obtained when two-dimensional imaging is used (0.25-7.7%) (4).

It is unilateral in most cases (1, 2, 11) and predominates in the permanent dentition (2, 4). Maxillary lateral incisors are the most affected (2, 11), followed by maxillary central incisors and supernumerary teeth (8). Its frequency in canines, premolars and molars is rare (14). Its appearance is concomitant with other anomalies, such as hypodontia, hyperdontia, macrodontia and supernumeraries (1, 2, 4). A genetic component is attributed to it (2, 4). It is not related to sex, age or systemic diseases (2). More than 50% of DI cases are type I according to Oehlers, followed by type II and III (2, 11). Approximately 20% of DI cases present apical pathology. Regarding their clinical appearance, more than 40% of cases present normal crown morphology, while the rest are amorphous, barrel-shaped and conical, respectively (2).

ETIOLOGY

Its etiology is still unclear, but it seems to involve both genetic and environmental factors (1, 2). Some of the theories that explain the etiology of DI are as follows:

- The result of an alteration in the signaling and interaction processes of a particular group of cells that are surrounded by cells that continue to proliferate normally.
- Due to the stimulation and proliferation of enamel organ cells within the papilla during tooth formation.
- Due to external mechanical forces that influence the tooth germ during development.
- Trauma and infections (4).

DIAGNOSIS

Early diagnosis of DI is important for prognosis (1). In the absence of clinical signs, DI can easily go unnoticed. Its presence increases the risk of caries, pulp and periapical pathology, internal resorption, and complicates endodontic therapy (2). Even before caries develops, interruptions in the invaginated enamel surface can allow microorganisms to penetrate into the canal system. The occurrence of apical periodontitis increases with increasing severity of invagination (8).

Clinical presentation

Often, the initial diagnosis is made according to the morphology of the crown. It varies from a normal presentation to a conical or barrel shape. A deep blind hole in the palatal or occlusal surface of the tooth is the entrance of the invagination (1).

Clinical presentations of DI can be (1):

- Presence of a palatal fossa or groove, resulting from a bifurcation of the cingulum (Figures 1 and 2).
- Barrel or cone-shaped teeth (Figure 3).
- Dilated crown with a larger mesiodistal and/or vestibulo-palatal diameter.
- Microdontic teeth.
- Presence of claw cusp or *dens evaginatus*, especially in cases of DIC type II.
- Presence of a labial groove associated with incisor notches, especially in the upper central incisors.

Supplementary tests

Two-dimensional radiographic images

It is the most widely used method to diagnose DI (1, 8). However, it has limitations, such as anatomical noise, geometric distortion and superimposition of images of other teeth and adjacent structures (4).

The reported radiographic presentations of DI are as follows (1, 7):

- Radiographic presentation of DIC type I: Linear radiolucent image of the fissure limited to the crown (Figures 1 and 3).
- Radiographic presentation of DIC type II: A radiolucent pocket with a radiopaque rim extending into the root as a blind sac without reaching the apical area and without connection to the periodontal ligament (Figure 2).
- Radiographic presentation of DIC type IIIA: Invagination is located laterally to the main canal, which extends from the crown to the apical third of the root and communicates with the periodontal ligament through a pseudoforamen.
- Radiographic presentation of DIC type IIIB: Invagination is centrally located within the main canal. Radiolucent lines are present both mesially and distally around the invagination.

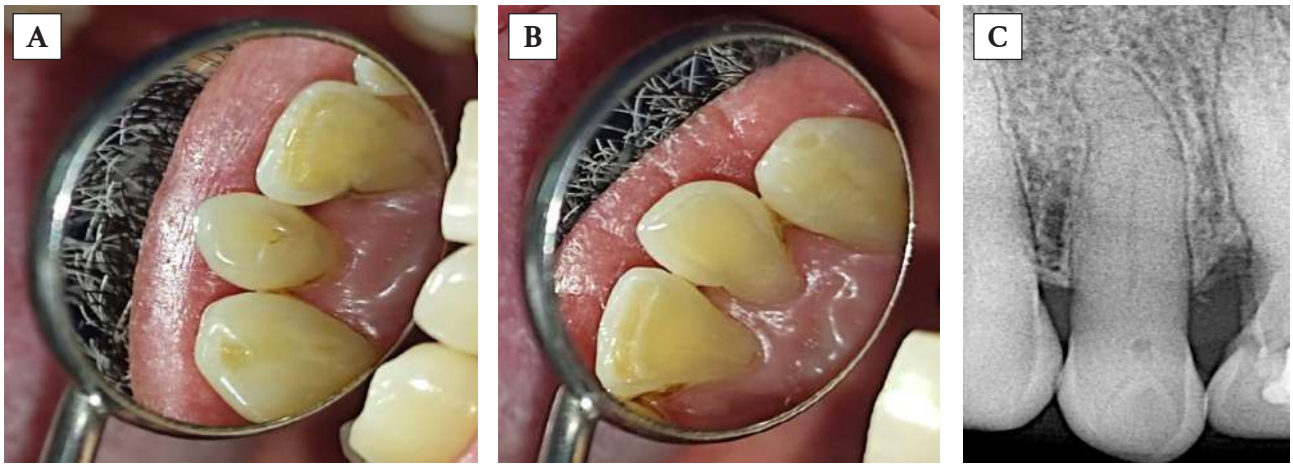

Figure 1. Tooth 2.2 (A) with *dens invaginatus* in the form of a palatal groove and its contralateral, tooth 1.2 (B), which presents normal anatomy (unilateral presentation). Periapical radiograph (C) of tooth 2.2, showing *dens invaginatus* type I according to Oehlers.

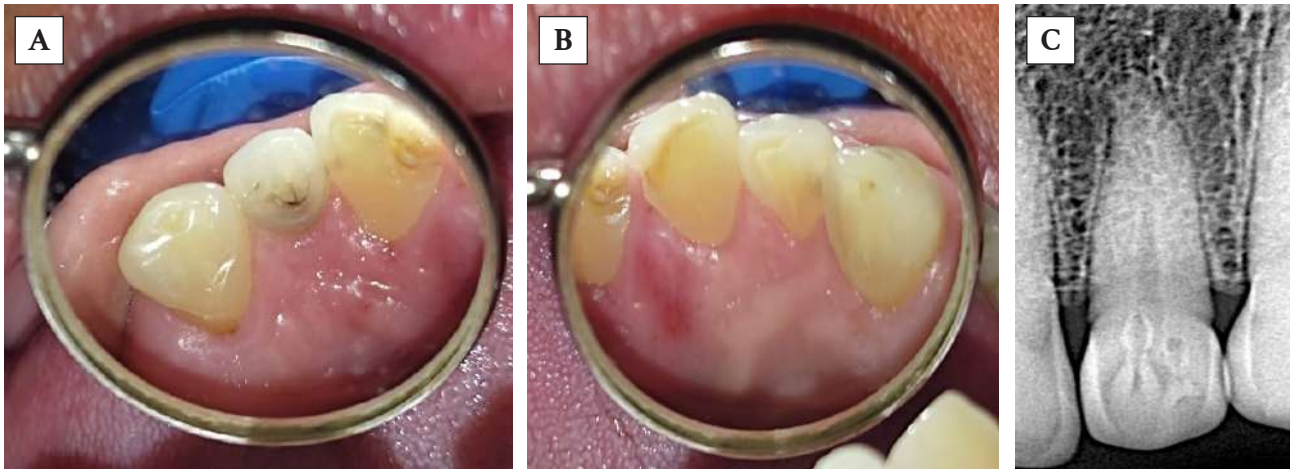

Figure 2. Tooth 2.2 (A) with *dens invaginatus* in the form of a palatal fossa and its contralateral, tooth 1.2 (B), which presents normal anatomy (unilateral presentation). Periapical radiograph (C) of tooth 2.2, showing two invaginations and *dens invaginatus* type II according to Oehlers.

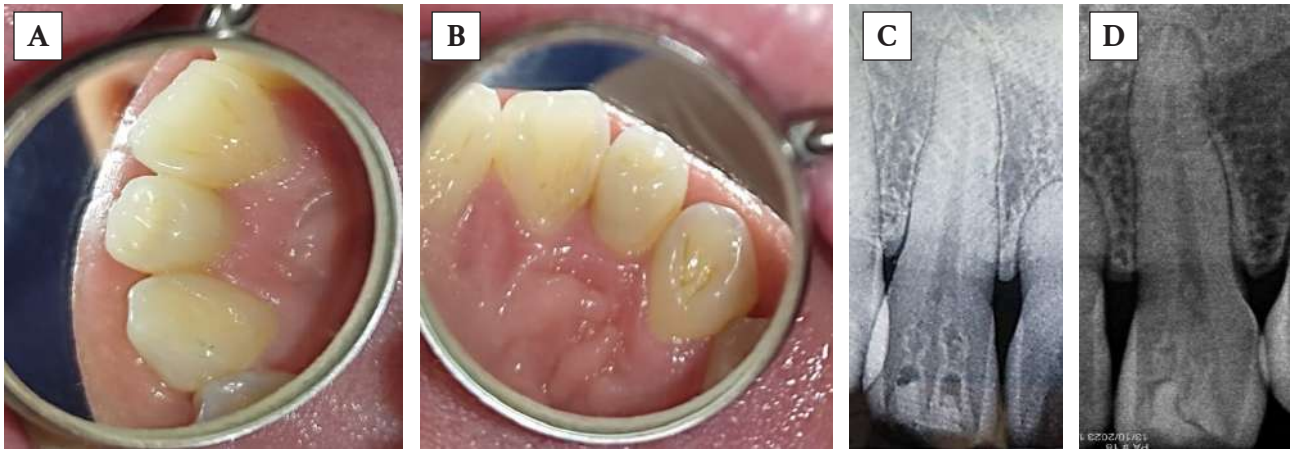

Figure 3. Teeth 1.2 (A) and 2.2 (B) with barrel-shaped dens invaginatus (bilateral presentation). Periapical radiographs of teeth 1.2 (C) and 2.2 (D), showing, respectively, two invaginations and *dens invaginatus* type I according to Oehlers.

Three-dimensional images

Three-dimensional images have far surpassed two-dimensional radiographs in terms of accuracy and detail. Today, SCT, CBCT and micro-CT have been introduced for the diagnosis and treatment of DI. The main difference between these techniques is the thickness of the section, a factor of great importance when evaluating the accuracy of images of the root canal system. SCT, CBCT and micro-CT slice thicknesses are 650-1000, 80-200 and 5-50 μm, respectively (1). The possible computed tomography representations of DI in cross section are as follows:

a. Invagination is in the central part of the main canal, and this appears as a hyperdense area surrounding the invagination.
b. Invagination is in the lateral part of the main canal, and this is shown as a C-shaped hyperdense area on one side of the invagination.
c. Invagination is in the central part of the main canal, and this is observed as two opposing hyperdense crescent-shaped areas.
d. Invagination is in the lateral part of the root, and the main canal is shown as a hyperdense area with no connection to invagination.
e. The main duct appears as a hyperdense area and may be rounded or C-shaped.
f. Only the hyperdense area of the main canal (1) appears.

Three-dimensional imaging techniques for the treatment and diagnosis of DI are as follows:

- **Spiral computed tomography (SCT):** It has lower accuracy compared to CBCT. It is useful for locating additional root canals, identifying the internal structure of a C-shaped canal and confirming anatomical variations of the root canal system (1).
- **Conical Beam Computed Tomography (CBCT):** It has low radiation dose, high resolution, accuracy, and requires less time for the evaluation of anatomically complex root canal systems. However, images lose quality in the presence of highly radiopaque objects (4). It is usually used for diagnose complex cases of DIC (types II and III) and DIR (1).
- **Micro-computed tomography (micro-CT):** It can only be used for the investigation of small samples. It is used for the analysis of the internal anatomy of the root of extracted teeth, of different instruments for root canal preparation and for the analysis of bone characteristics (1).

TREATMENT

DI complicates both diagnosis and treatment in any tooth (1), due to the anatomy, canal system and incorporated invagination (10, 15). In the deciduous dentition, extraction is suggested when the tooth is impacted, crowded, supernumerary or if there is a periapical lesion affecting the permanent tooth germ. Otherwise, composite resin should be selected based on the condition of the pulp (1, 3). In the permanent dentition, treatment varies according to the type and shape of the malformation. Treatment options range from preventive sealing to regenerative endodontic therapy (10). In all cases, the aim is to maintain the vitality of the pulp and preserve the tooth structure by means of a minimally invasive method (2).

Treatment of DIC type I

Different sealing methods can be used, depending on the initial depth of invagination (3). When this is minimal and limited to the crown, prophylactic filling with composite resin or pit and fissure sealant is chosen. In limited pulpitis and immature teeth, pulpotomy should be considered. If the pulp is extensively infected or there is a periapical lesion, root canal treatment is required. In case of an immature root, regenerative endodontic therapy is chosen. When root canal treatment fails, it can be complemented with surgical therapy (1). In exceptional cases, it may present deep periodontal pocket with vital pulp, which is treated with surgery and preventive treatment with mineral trioxide aggregate (MTA) (3).

Treatment of DIC type II

If the affected teeth have pits or grooves without dental caries, preventive sealing is the first option. If the invagination has caries and the pulp is intact, sealing with composite resin, amalgam or glass ionomer can be chosen, after disinfection with chlorhexidine or 1% sodium hypochlorite (3). Most caries in DIC type II are associated with irreversible pulpitis or pulp necrosis, which makes root canal treatment unavoidable (3). In these cases, the main canal and the invaginated canal are treated separately. However, residual debris from the invaginated canal affects the cleanliness and obturation of the main canal. If the invagination is close to the amelocemental junction, it should be removed during coronal widening. If, on the other hand, it

extends into the middle or apical third of the root, it is removed with the aid of microscopic techniques, magnifying loupes, passive ultrasonic irrigation (PUI) and hand instruments. In an immature root, apexification may be the main choice (16), although recently there have been reports of cases successfully treated with pulp revascularization (PR), maintaining the canal walls and reducing the periapical radiolucent area (1).

Treatment of DIC type III

It depends on the state of vitality of the pulp and two options are chosen: separate treatment of the invaginated canal while maintaining the vitality of the main canal or treatment of both canals in case of pulp necrosis (3, 17).

When the main canal is immature with an open apex, apexification or pulp revascularization is suggested. In such cases, MTA, Biodentine and collagen membranes have proven to be appropriate as an apical barrier. In type IIIA, apexification fails to form a hard tissue barrier due to the low regenerative capacity of the cells around the lateral pseudo-hole. In contrast, in type IIIB, better results are obtained because the main and invaginated canals communicate with the periodontal ligament (3).

Low speed Gates Glidden burs or K and H files, which allow good operator control, can be used for instrumentation of the tooth (1). Machined instruments should be used with caution in the invaginated canal due to its irregular shape and the enamel coating in this area which could further weaken the tooth. Passive ultrasonic instrumentation has also been shown to be effective in these cases (5).

Irrigation with 2.5% sodium hypochlorite is essential, as it cleans and accesses areas that manual or rotary instruments cannot reach, without altering the dentin structure or the characteristics of the root canal. A continuous irrigation of 5 mL of 17% EDTA for 3 min into the root canal is also suggested to remove the smear layer and expose the dentinal tubules (6).

As an intraoral medication, the use of calcium hydroxide is suggested for at least 21 days, especially in cases of necrotic teeth with periapical lesion (6).

For obturation, the lateral compaction technique or thermoplastic obturation is used, as they allow the softened gutta-percha to enter inaccessible areas. It is also proposed to associate the lateral compaction technique with a bioceramic sealant to fill the canal irregularities; however, there is a risk of sealant extrusion when the apex is open (6).

The association of non-surgical and surgical endodontic therapy (CBCT, surgical microscope, magnifying loupes, machined instruments and bioceramic sealants) are important to ensure a predictable result in type III DIC (6, 18). Extraction is the last resort when the above-mentioned fails (19).

DIR Treatment

Treatment options such as endodontic intervention, periapical surgery, reimplantation or extraction may be considered (3). Due to insufficient understanding of the internal root structure in reported cases of DIR, extraction is usually chosen rather than some effort to save the teeth. However, if the affected teeth are indispensable for esthetics or masticatory function, extraction should be considered with great caution (1).

PROGNOSIS

A sufficiently large sample has not yet been studied to allow definitive conclusions about the prognosis of this anomaly. However, the cases reported so far with follow-up periods from 6 months to 27 years indicate a good prognosis (17). It is also evident that, as new technologies are developed and used, the prognosis of this anomaly will improve considerably.

DISCUSSION

DI is a dental anomaly that implies a special consideration in endodontics due to its complex clinical and radiographic presentations, which lead to rapid progression of carious lesion, pulp and periapical disease. In addition to its high prevalence in permanent anterosuperior teeth, it is a situation that affects the quality of life of the individual, both esthetically and functionally. Therefore, it is of utmost importance to know its etiology, prevalence, classification and clinical and radiographic characteristics for early diagnosis and timely treatment.

There is a consensus regarding the unknown etiology of this anomaly and the theories that suppose its formation are many (1, 2, 4). Most of them are due to genetic and intrinsic factors over which there is no control. However, there are also extrinsic causes resulting from traumas and infections that deserve special caution, especially at early ages.

Despite the passage of many years, the classification proposed by Oehlers in 1957 is still in force and is

preferred by the dental community due to its simple nomenclature and easy application. This classification divides DI into three types: type I, type II, type IIIA and IIIB (1, 7). However, Kritika et al. (8) proposed to extend this classification into three additional subtypes for type II DI. At the same time, Gul et al. (9) proposed a type IV DI in an upper incisor. Both proposals in recent years respond to the need to develop more specific treatment protocols according to the type of case.

Regarding the prevalence of DI, the results obtained in research in recent years are different. Kfir et al. (11) found a prevalence of DIC of 26% in an Israeli population, with a similar prevalence rate among men and women. Alexoudi et al. (12) reported that the prevalence of DI ranged from 0.3 to 26% (12). Yalcin et al. (2) found a prevalence of DIC of 5.11%, with a higher frequency in female patients. While Hegde et al. (13) reported a prevalence of DI of 1.1% in an Indian population, with a higher frequency in females than in males. Finally, González-Mancilla et al. (4) reported a prevalence of DI of 0.090 (95% CI): 0.072-0.108; $p < 0.001$), with no significant differences by sex, in studies that made use of CBCT as a diagnostic aid. The difference in these results is probably determined by the ethnic characteristics of each study population and by the different diagnostic criteria and methods used. Regarding the latter, CBCT has demonstrated a statistically higher prevalence for the detection of DI than that obtained using two-dimensional imaging (4). This may be due to the greater accuracy of CBCT in identifying the complex anatomy of the canal system, thus representing an effective and essential tool for the diagnosis of this anomaly.

Although most studies report a higher prevalence of type I DIC with regards to the other two types (II and III) (2, 4, 11), Hegde et al. (13) reported a higher prevalence of type II DIC in an Indian population, with the following results: type I (22.1%), type II (61.03%), type IIIA (10.4%) and type IIIB (6.5%). Again, this may be due to the ethnic characteristics of the population studied.

Treatment varies according to the clinical and radiographic characteristics of each type of DI (10) and its consequent hard tissue, pulp and periapical conditions. Volodymyr (3) reported, in a literature review, that treatment options for type I DIC generally range from preventive sealing, root canal treatment to apexification. However, there are exceptions such as the one reported in the review by Zhu et al. (1), where three cases of type I DIC with immature root were treated with apexification, while surgical intervention was necessary due to lack of symptomatology control.

As mentioned before, most cases of DIC type II are associated with irreversible pulpitis or pulp necrosis, so literature reviews of the last 5 years (1, 3) report proposals focused on root canal treatment in concomitance with the use of microscopic techniques, magnifying loupes, PUI and hand instruments. In this context, Zubizarreta-Macho et al. (16) propose the use of splints made by three-dimensional digital impression that would allow precise, conservative and safe cavity access to teeth affected by anatomical malformations.

Type III DIC cases are often difficult to manage due to their complex root canal system. Pradhan et al. (5) propose the use of CBCT as an effective diagnostic aid, ultrasonic instrumentation for the removal of infected tissues and the use of digital optical microscopy for better visualization of the canals. In their case report, they said they used the Schilder hot vertical compaction technique for the final obturation. Fonseca et al. (6) also made use of CBCT to accurately and clearly determine the anatomy of DIC type III. As a filling technique, they used the lateral compaction technique associated with a bioceramic sealant, which generated a better obturation of the root canal due to the excellent fluidity of the cement. At the same time, they considered the use of an operating microscope to be essential for the success of the case. Abu Hasna et al. (15) made use of the lateral compaction technique to treat a case of type III DIC associated with periapical lesion. However, they used two-dimensional radiographs for diagnosis and indicated that DI associated with periapical lesion can be treated with nonsurgical endodontics, resulting in an acceptable resolution of the periradicular lesion after 6 years of follow-up. Arora et al. (17) also made use of two-dimensional radiographs to diagnose a case of DIC type III and digital optical microscopy to improve access to the cavity and used a combined technique of lateral condensation and vertical compaction of gutta-percha with a sealer. Lee et al. (18) made use of periapical radiography and CBCT to diagnose a case of DIC type III. They employed a surgical operating microscope to carefully explore the root canal and MTA to fill and seal the pseudo-root canal. DIR cases generally have a poor prognosis, and the treatment of choice is extraction (1, 3), probably due to poor knowledge of the internal root anatomy.

Although studies with larger samples are still needed to draw definitive conclusions about prognosis (17), the studies already reported show a favorable prognosis

in most cases due to the use of new technologies in combination with non-surgical and surgical endodontic therapies (6, 18), which will ensure clinical success.

CONCLUSIONS

Although the etiology of DI is still unknown, its high prevalence warrants an exhaustive and early diagnosis with three-dimensional imaging, such as CBCT, in concomitance with conventional and emerging methods. The clinical and radiological criteria to be considered before choosing the treatment are the following: type of DI, depth of invagination, proximity of the invagination to the pulp, its projection into the main root canal, possibility of adequate root canal treatment and infection control, pulp vitality, condition and size of the apex, accessibility to the instruments and materials necessary for the planned treatment. All this would lead to choose the best intervention protocol according to the case of DI presented in the consultation, generating favorable results in less time and with better prognosis.

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CASE REPORT

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Management of the anterior sector altered by impacted central incisor and ectopic eruption of canine: case report

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ABSTRACT

Tooth loss is common during childhood following bucco-dental trauma. Space management is an important issue that should be planned from an early age. Failure to intervene in a timely manner can lead to impacted permanent teeth, crowding, alterations in the eruption of neighboring teeth or malocclusions. This case report describes the dental management performed by a multidisciplinary team that included pediatric dentistry, orthodontics, maxillofacial surgery and periodontics after dental avulsion and subsequent dental impaction and ectopic eruption. The treatment applied consisted of exodontia of the primary canine, distalization of tooth number 23 for correct placement and subsequent traction of tooth number 21, using fixed appliances. If there is premature loss of primary teeth in the anterior sector, the patient should be referred to a specialist to avoid possible consequences. The indicated therapy will depend on each particular case, individualizing needs, costs and benefits. The intervention in these cases should be timely by the treating team, especially when the child is in an important stage of development, both physically and psychologically. The resolution of complications in the anterior sector should be managed by a multidisciplinary group.

Keywords: odontological practice; impacted tooth; space maintenance; case report.

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ADC: Research, supervision, writing – review & editing.

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INTRODUCTION

Primary teeth are of utmost importance for the growth and development of a pediatric patient. They play a role in phonetics, esthetics and chewing. Their other role is to maintain the space for the permanent tooth number (TN) until it emerges into the oral cavity. Following premature tooth loss, space maintainers not only safeguard function and preserve arch length, but also safeguard esthetics and eliminate any potential psychological damage a child might face because of premature tooth loss. At the same time, space maintainers provide a space for proper alignment (1).

Maintaining arch length in the primary, mixed and early permanent dentition is important for normal occlusal development. Premature loss of primary teeth can limit arch length and lead to malocclusion. The lack of space is influenced by aspects such as the patient's age, stage of development, dental losses, molar relationships, crowding or diastemas (2); and in the primary dentition it is one of the causes of malocclusions in permanent teeth (3).

However, maintaining space can reduce the need for prolonged orthodontic therapy. The choice becomes more complicated when the first permanent molar has not erupted (4). There is no solid scientific evidence about the consequences after premature loss of primary anterior teeth. Negative aspects are reported, such as alterations of impaction and eruption of permanent teeth, inclination of neighboring and antagonist teeth, respectively, deviation of the midline and crowding. It is possible to find functional problems such as speech disorders, esthetic problems, development of non-nutritional habits, leading to psychosocial implications, including decreased self-esteem and even being bullied (5).

Premature loss of primary teeth may follow oral trauma, extractions, early childhood caries, periodontal disorders, or be a manifestation of a systemic disease (6). Tooth eruption involves an axial displacement of the teeth from their place of formation in the alveolar bone to their functional position in the oral cavity. For this reason, delayed tooth eruption can have a significant impact on proper patient care (7).

The impaction of permanent teeth is a challenge for the professional when making a diagnosis, designing a treatment plan and determining a prognosis. There is a connection between primary teeth and the germ of permanent teeth, and any lesion to the primary dentition may influence the eruption of the permanent teeth. The extent of damage caused to the permanent tooth germ will depend on the age of the patient at the time of the lesion, the type of trauma, the severity and direction of the impact (8).

Every year, many children suffer oral injuries and carry their consequences. Among the causes, direct trauma to objects, falls or facial and oral impacts stand out. Sequelae in the permanent dentition are not widespread in the long term, even though the oral region is the second most regularly injured part of the body in children under 6 years old. During this stage, the developing permanent teeth can be altered after trauma, causing mild or severe dental hypoplasia, displacement, injury to the tooth germ, impacted or retained teeth, or morphofunctional alterations. Occasionally, the consequences will be seen when the permanent incisors erupt, with ectopic or non-aligned eruptions. Therefore, patient follow-up is crucial to diagnose and treat the associated complications. Early referral to a pediatric dentist for diagnosis and treatment planning should also be emphasized (9).

CASE REPORT

A 9-year-old male patient who comes to the dentist with his mother. When asked about the reason for his visit, he replied: "I am here because I don't have a tooth." The mother indicates that the patient is the product of a twin pregnancy, healthy, without systemic complications. Regarding sociodemographic data, she comments that they are from Valencia, Carabobo in Venezuela, a high school student, and they live in their own home with their mother, that is, their maternal grandmother. Besides, she denies any type of allergies, medication consumption or surgical interventions. She was asked about the presence of oral habits, to which she reported no presence. A dento-facial trauma was identified at 18 months with subsequent dental avulsion, specifically of the upper left primary incisor (TN 61). Among the family history, the mother only refers that the father died of COVID-19 in 2020. It is important to mention that the mother signed an informed consent form at the beginning of the visit to the dentist.

At the initial clinical examination (Figure 1), there is an absence of upper dental number. And at the initial radiographic examination (Figure 2), the panoramic radiograph shows a lack of eruption of the upper left permanent central incisor (TN 21), with deviation towards the mesial of the upper left permanent canine (TN 23) without eruption, in intimate contact with the root of the upper left permanent lateral incisor (TN 22). We can see the presence of a radiolucent area

in the incisal third of TN 21, presumably associated with a defect in the development of the enamel, specifically enamel hypoplasia. It presents a pattern of dental exfoliation according to age in the lower sector, stage 8 of Nolla.

Figure 1. Initial photos of the patient. A) Frontal smile; B) Frontal occlusal.

Figure 2. Initial panoramic X-ray.

There is no evidence of supernumerary teeth or dental agenesis. In the axial and frontal images of the computed axial tomography, the lack of eruption of TN 21 and its proximity to TN 23 can be observed, as well as the root dilaceration of TN 22 (Figure 3). On extraoral examination, a slightly convex facial profile was observed; and on intraoral examination, normal *overjet* and *overbite* were observed, without crowding, dental midlines coincided with the facial midline, class I molar.

Figure 3. Computerized axial tomography of the patient.

Regarding the treatment plan, a multidisciplinary proposal was made by a pediatric dentist, an orthodontist, a maxillofacial surgeon, and a periodontist. The treatment alternatives were as follows: 1) extraction of TN 23 and 63, closing spaces with orthodontics, sacrificing TN 23 and making traction of TN 21; 2) extraction of the primary canine (TN 63), distalizing TN 23 for correct placement and subsequent traction of TN 21. The last option was chosen because of the possibility of distalizing the canine and placing it in position without eliminating another tooth.

Initially, the upper left primary canine was exodontia to improve the eruption corridor of the upper permanent central incisor. In the initial orthodontic phase, fixed appliances with a prescription of Roth slot 0.22 are placed exclusively in TN 24, 25 and 26, in addition to a mini-screw as absolute anchorage in the left molar area for distal traction of the upper canine (TN 23) to avoid undesired mesialization when consolidating this sector. By placing TN 23 in its correct position, TN 21 erupted posterior to unblock that space. After observing that this tooth was erupting, a surgical eyelet was performed and a *bracket* was cemented in TN 21 and in the rest of the upper arch to continue with the steps of alignment and leveling, following the sequence of arches with normal corrective orthodontics (Figures 4 and 5).

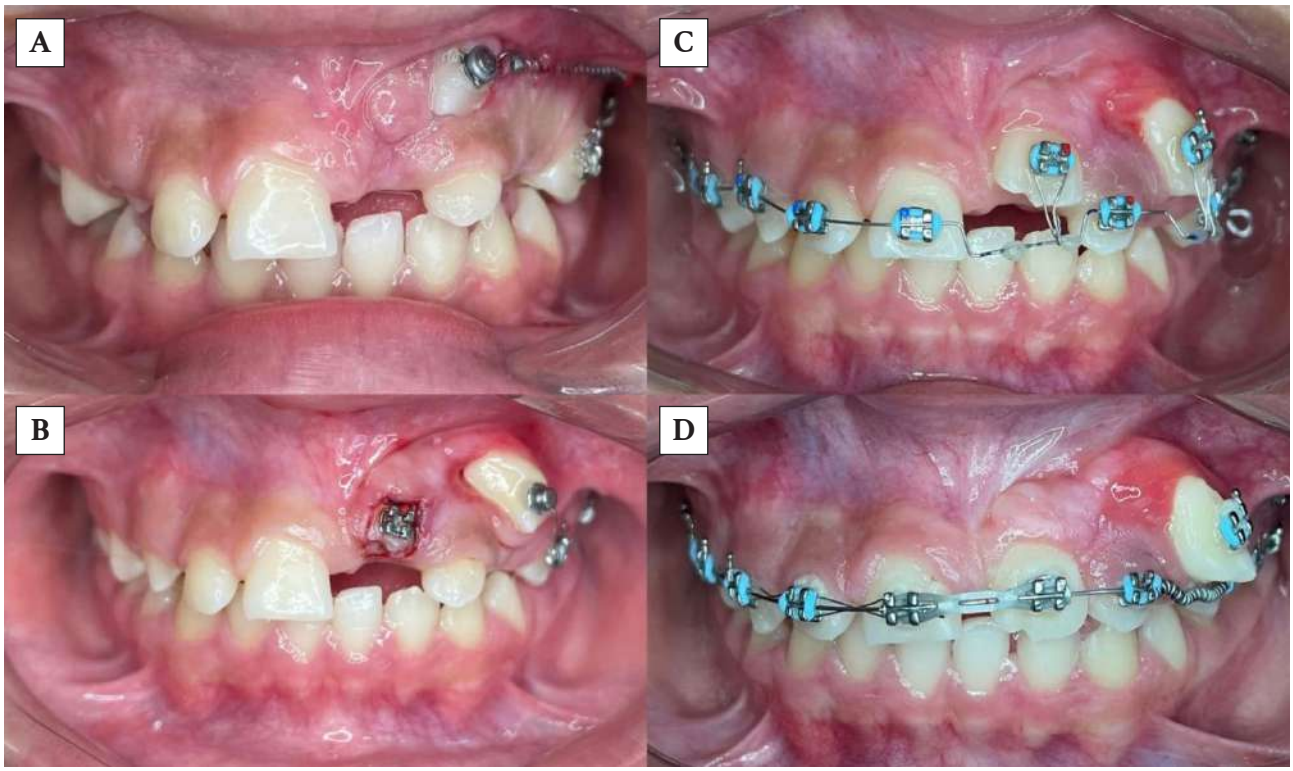

Figure 4. Evolution of left upper canine traction with the aid of a miniscrew. A) Distalization of TN 23 with closed nitinol spring to the absolute anchorage (miniscrew); B) Distalization of TN 23 completed, leaflet and bracket cementation on TN 21; C) Orthodontic mechanics of alignment and leveling with distance traction of TN 21 and 23; D) Working phase for space management and placement of TN 23 in the dental arch.

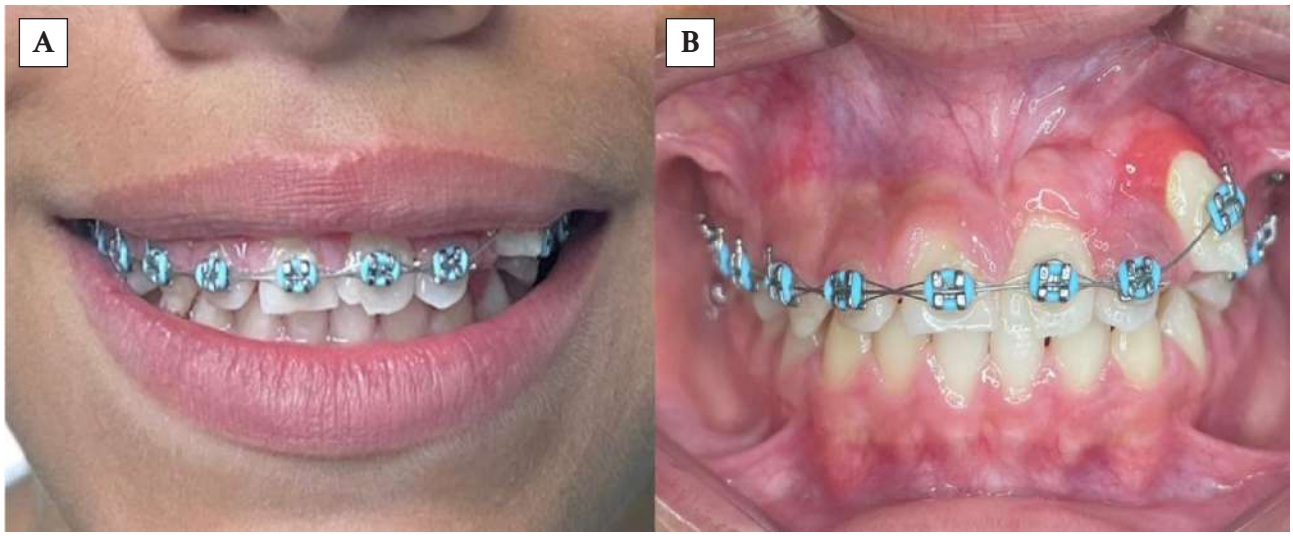

Figure 5. A) Orthodontic alignment and leveling phase; B) Space consolidation, alignment and leveling of TN 23.

When the teeth were correctly positioned, it was observed that the patient had an asymmetrical gingival topography, so gingivectomy and gingivoplasty of the anterosuperior sector were performed to obtain a more esthetic and physiological contour of the soft tissue (Figure 6). Following an order, an excess of keratinized gingiva is observed in some teeth. For example, a very narrow band can be identified in TN 23. In addition, adjustments in dental esthetics are necessary to harmonize the dental anatomy, which also has an impact on the evaluation of esthetic parameters.

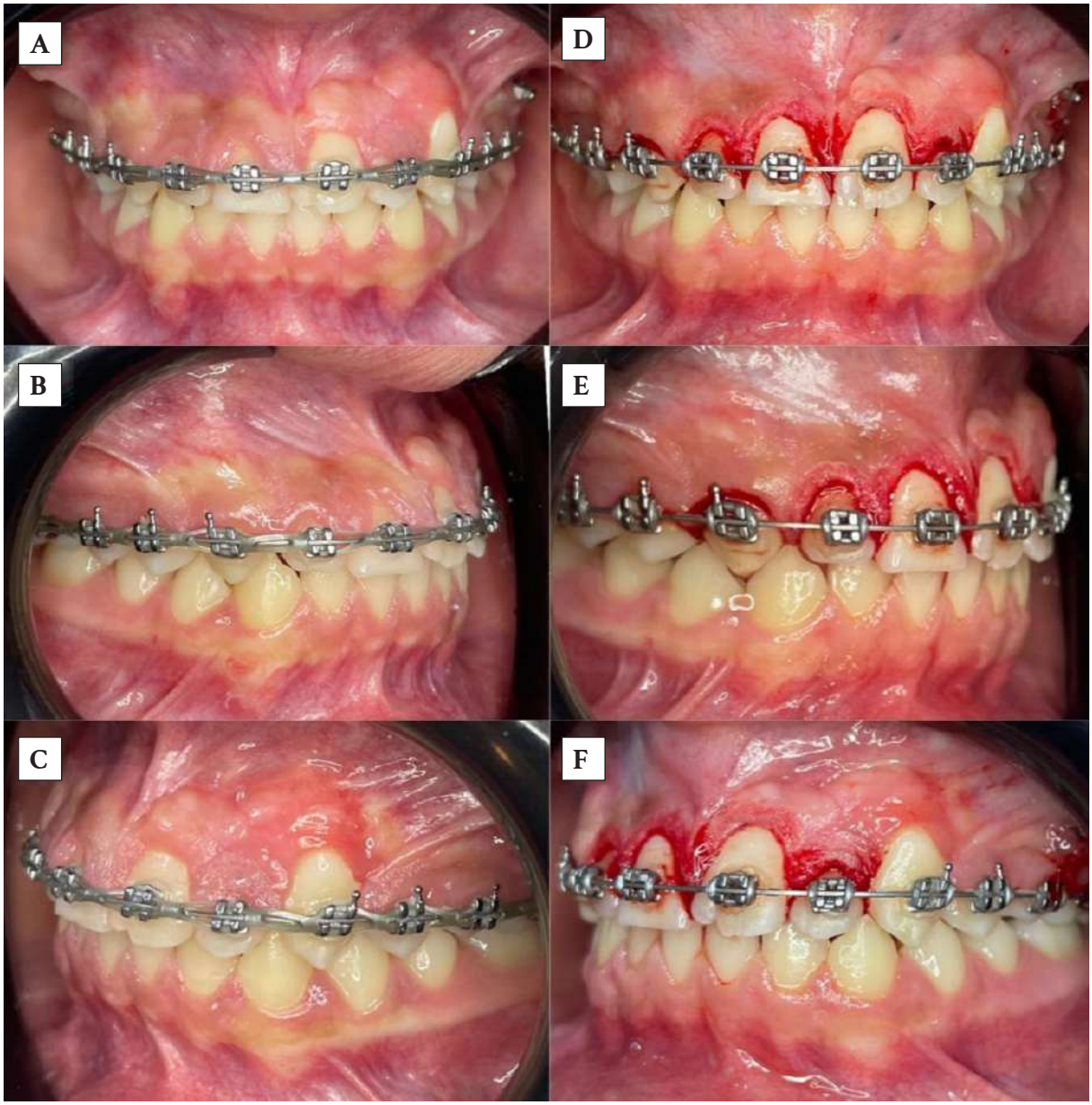

Figure 6. A) Front photograph in maximum intercuspation prior periodontal treatment; B) Right side photograph in maximum intercuspation prior periodontal treatment; C) Left side photograph in maximum intercuspation prior periodontal treatment; D) Front photograph in maximum intercuspation after performing gingivectomy and gingivoplasty in the anterosuperior sector, preserving an adequate amount of keratinized gingiva; E) Right lateral photograph in maximum intercuspation after performing gingivectomy and gingivoplasty only touching TN 13, preserving an adequate amount of keratinized gingiva; F) Left lateral photograph in maximum intercuspation, where no periodontal procedure is performed due to the defect present in the contour of TN 23.

The case is not finished, there is still asymmetry at the level of the gingival contour, but the evolution of the orthodontic treatment is expected to perform a single gingival procedure according to the needs of each area. The next step is to finish with conventional corrective orthodontics, with cementation of the lower appliances, with a sequence of archwires until finishing with removal and retention. For economic reasons, the patient has not completed all phases of treatment. It was the aesthetic problem that made the mother look for help. Upper completion is proposed exclusively because the primary occlusal parameters are present: class I molars and canines, midlines, firm interdental contacts, no gaps and acceptable dental inclinations.

DISCUSSION

Tooth loss in anterior teeth should be managed from an early age. Space management is paramount in the initial stage to avoid future consequences. The prevalence of dental trauma in male patients is higher than in female patients, as is the frequency of impacted teeth (10). This case report is of a male patient whose initial dental trauma was at 18 months of age, which resulted in dental avulsion and subsequent impaction of the permanent successor tooth. Upper central incisor impaction is a rare phenomenon that affects the facial appearance of a pediatric or adolescent patient with esthetic and functional implications, with the central incisors being of vital importance for the smile, lip support and food incision (11).

In this case, the patient was a pre-adolescent who could hardly express himself and smile due to the absence of a central incisor. The upper incisor teeth generally erupt in the early mixed dentition, but alterations in eruption can occur and are often attributable to local factors. A failure in eruption will affect the development of occlusion and will have an influence on psychological aspects of the child. The main thing is to provide space in the dental arches and to avoid any impediment to the correct eruption of the tooth. Therapeutics should include a careful clinical evaluation, and a specialized multidisciplinary approach is recommended to optimize the treatment outcome (12).

Although the patient had the indication of space maintainer after dental avulsion, the lack of use over time resulted in the impaction of the upper central incisor. The potential benefits of the use of appliances are the reduction of ectopic eruptions, malocclusions such as crossbites, dental impactions and alterations in molar relationships. There may also be a cost reduction in orthodontic treatment. Duward (2) believes that careful consideration of many factors is required when deciding whether a space maintainer is indicated. In this case, there was a treatment plan for the installation of a fixed space maintainer. However, in the face of constant dislodgement of the device, the parents decided not to follow the treatment. Ahmad et al. (13), in their review, found no strong evidence in favor of a particular method of space maintenance. At the same time, they showed that evidence to evaluate the achievement of clinical objectives, patient preference and device costs were poor, and recommendations cannot be made based on these results. When evaluating the best method of space maintenance, much depends on longevity and efficiency results. Failure rates varied widely among the studies. This statistic shows that this type of intervention does not always give satisfactory results; however, it should also be noted that more studies are needed to support these data.

A retrospective study conducted in Saudi Arabia determined the prevalence of late eruptions of the upper permanent central incisors, using panoramic radiographs of subjects aged 6 to 10 years attending university hospitals, between 2014 and 2020. Radiographs were analyzed to determine the delayed eruption of the upper permanent central incisors. They identified late erupting upper permanent central incisors according to the stages of tooth development and eruption sequence. Retention of primary teeth was the main factor causing delayed eruption, followed by early loss of primary teeth and lack of space in the arch (7). It is important to point out that in this case report it was not a primary tooth retention, but tooth avulsion, which was a premature loss before the age of 2, and that the space maintainer was not used correctly over time. In contrast to this case report, Yordanova and Gurgurova (14) mentioned that the most frequent cause of impaction of the upper central incisor was the presence of supernumerary teeth, specifically mesiodents, consequent to the presence of follicular cysts and odontoma or a sum of both.

In a study conducted in patients with traumatized teeth, dental anomalies in the permanent successor teeth were detected in 21 patients, in 26 teeth and 28 anomalies. Most frequently found were anomalies of the eruptive process, then enamel hypoplasia and white spots. If the trauma was in children younger than 36 months, the percentage of anomalies was found to be more frequent. Intrusive and extrusive

luxations were linked to clinical alterations in the successor permanent teeth. The risk of dental anomalies following trauma in the primary dentition is pointed out in this research (15). In the present case reported, when analyzing the panoramic radiograph, an image was observed in the area of the incisal third of the upper left permanent central incisor, which upon eruption was found to be a dental hypoplasia. At the same time, when posterior radiographs were taken, root dilaceration was observed in the lateral incisor on the same side (Figure 7). De Amorim et al. (16) found, among a group of 815 traumatized primary teeth, that the most common sequelae observed in successor teeth were enamel discoloration, dental hypoplasia, and root and crown dilaceration. All these data coincide with the oral manifestations found in the present case report.

Figure 7. Control panoramic radiograph to observe the location of TN 22 and 23, without the presence of root resorptions.

Results found by Santo Jacomo et al. (17) report very similar statistics. The most common developmental alterations were enamel discoloration and/or enamel hypoplasia and eruption alterations due to traumatic injury in their predecessors. It was not possible to find an association between the type of lesion in primary teeth and damage to their successors in the age groups studied. The study concluded that enamel opacities and/or enamel hypoplasia were the most prevalent consequences in the permanent dentition and that there was no statistically significant association between the occurrence of sequelae in permanent teeth and the type of traumatic injury to their teeth.

In the present case, a dilaceration was found in the lateral incisor, which is defined as a dental anomaly characterized by an abrupt deviation in the longitudinal axis of a tooth. It can occur in the crown, between the crown and the root, or in the root. Despite not being so prevalent, retained upper incisors with root dilaceration represent a diagnostic and treatment challenge for the clinician. Dilaceration is observed as a tooth deformity with an angulation between the crown and the root, which can interrupt the eruption of the incisor. In this case report, it was not the impacted tooth (TN 21) that presented root dilaceration, but the neighboring tooth (TN 22) and the upper canine (TN 23).

Corroborating the above, Tan et al. (19), in their research on impacted teeth, found that the upper permanent central incisors were the most affected

teeth (70.6%). The most common causes of unerupted incisors were dilacerations (n = 83; 36.7%) of the upper central incisors; anomalies of tooth development (n = 22; 30.6%), along with unfavorable root development (n = 22; 30.6%) for the upper lateral incisors and abnormal tooth/tissue ratio (n = 11; 50.0%) for the lower incisors. Most of the unerupted incisors had sequelae, including ectopic position/displacement/rotation of the unerupted incisors (46.6%), space failure (36.9%) and midline displacement (27.5%), which is very similar to the present case report, in which lack of space, dental impaction, eruption disorder of other teeth, presence of dental anomaly such as dental hypoplasia and root dilaceration were found.

The concepts of gingivectomy and gingivoplasty generally go hand in hand, and are indicated in cases of supraosseous grooves, grooves larger than 3 mm, when there is no need for osseous surgery, asymmetrical and unsightly gingival topography, gingival elongation. Due to these reasons, the patient underwent such interventions.

It is important to mention that smiling starts at a very early age and it is a mechanism through which the individual expresses him/herself and receives encouragement. Over time, other concepts, such as self-image and self-esteem, are strengthened according to what the individual observes or the appraisals he or she receives from parents, relatives and peers. Oral health encompasses an integral concept where these variables must be taken into consideration, emphasizing that it is a fundamental basis for the quality of life of children and adolescents. Subjects with dentobuccal disorders have more difficulty in acceptance and socialization than their non-disordered counterparts, and the dental professional can offer changes to help improve self-image and self-esteem (20).

Even though this case report had limitations, such as the lack of completion of orthodontic treatment, the evolution observed in the resolution of the imbalance resulting from premature tooth loss in the anteroposterior sector, carried out by a multidisciplinary team, was very satisfactory (Figure 8). Over a period of 18 months, solutions have been provided to a list of problems presented by the patient, such as impaction of TN 21, lack of spaces, proper placement of TN 22 and 23, alignment and management of periodontal tissues. Consequently, this individual is a patient who can smile and interrelate with his peers without any type of complex, as it was not the case before treatment.

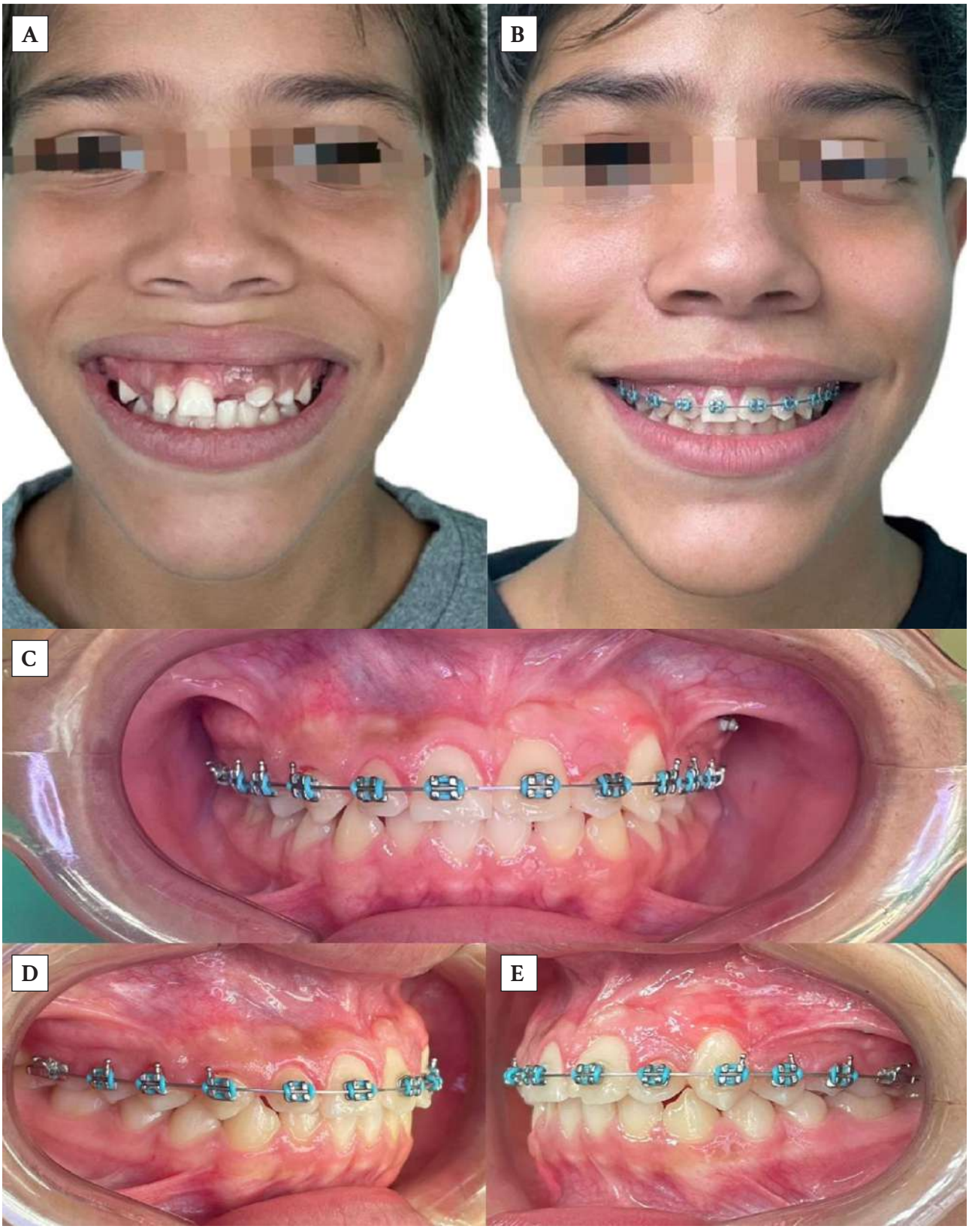

Figure 8. A) Pre-treatment facial forehead photograph; B) Post-treatment facial forehead photograph; C) Intraoral forehead photograph at maximum intercuspation after completion of treatment; D) Post-treatment intraoral right-sided photograph at maximum intercuspation after treatment; E) Post-treatment intraoral left-sided photograph at maximum intercuspation after treatment.

CONCLUSIONS

After premature loss of primary teeth in the anterior sector, the patient should be referred to a pediatric dentist to maintain the space. The indicated therapy will depend on each case, individualizing needs, costs and benefits. Resolution of complications following lack of space management should be managed by the orthodontist, maxillofacial surgeon and periodontist, if necessary. By making a treatment plan in conjunction with several specialties, the patient is given the possibility of solving his problem in a short time, channeled to a success that translates into esthetics and function. From this specific case report, it can be concluded that dental traction through orthodontic treatment works satisfactorily in dental impaction.

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Previous odontological practice of a clinical case in haptic simulation prior to patient treatment

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ABSTRACT

This descriptive, cross-sectional study addressed students' perceptions of a previous practice of dental preparation for a metal-free crown, performed in a clinical case using haptic simulation prior to patient treatment. The sample consisted of six final year Odontology students who, using haptic simulation with scanned images of the patient's mouth, milled metal-free crowns prior to treatment. The information was collected by means of two surveys. It was obtained that 66.7% (n = 4) of the students considered this experience to be very useful; and 83.3% (n = 5) mentioned that the experience gave them the confidence to perform the intervention on the patient. The results suggest that recurrent practice in haptic simulation of a clinical case, prior to treatment, is favorable for performance and provides greater security to perform it.

Keywords: teaching; Odontology students; perception; computer simulation.

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INTRODUCTION

The term "haptic", which until a few years ago was unknown, is no longer so, especially for most professionals dedicated to teaching; and in the field of dental education, its use is gradually increasing due to the advantages of this technology. This is not only because it is a practice that simulates real situations without exposing patients to possible risks, but also because it has a feedback system that provides a more standardized evaluation and allows the student to have a more independent training.

Haptic simulators provide the student with recurrent and safe practice on standardized cases. The possibility of repeating it allows correcting errors in each attempt, and it is used as another strategy for the development of clinical skills that positively influences their self-efficacy, which will generate confidence when performing these procedures on patients (1). Haptic simulators are useful for developing many of the manual skills required to perform various dental procedures, such as working with indirect vision with a mouth mirror, removal of carious tissue, dental preparations for fixed prostheses, among others (2).

In the literature, we can appreciate different educational experiences that have arisen with the use of haptic simulators, such as the one reported by a dental training center in Amsterdam, where they introduce practice in these simulators from the first year of studies with activities to develop and enhance their psychomotor skills and whose complexity increases gradually, using direct and indirect vision (3).

On the other hand, the use of intraoral scanners is increasing in the clinical practice of dentistry, which demands their introduction in the contents taught to future professionals in the area. In that sense, many faculties are acquiring this technology as part of the resources used in clinical courses for dental procedures in real cases; however, this technology can be used in combination with haptic simulators to facilitate learning. Therefore, the aim of this study was to describe students' perceptions of the practice of a metal-free crown tooth preparation of a clinical case in haptic simulation prior to patient treatment.

MATERIALS AND METHODS

This research is a cross-sectional study using a convenience sample of six clinical internship students who agreed to participate voluntarily. They received theoretical and practical training on the procedure for the fabrication of metal-free crowns, which included two master classes and two practical workshops on tooth preparation for metal-free crowns, scanning technique, design, milling, staining and cementation. Subsequently, the cases of their patients who were to undergo this procedure were scanned. This image was exported to the haptic simulator as an STL file and the student performed the dental preparation, which was evaluated by the professor in charge using a checklist prepared by the teachers in the area. The experience was repeated until getting the professor's approval, and then the treatment on the patient was executed.

Students' perception was collected after practice on the haptic simulator and after the patient intervention, using two surveys validated by judges' criteria.

RESULTS

The students' perception of this learning experience is shown in Table 1, which shows that 66.70% (n = 4) considered it as a very useful experience. At the same time, 83.30% (n = 5) indicated that performing the practice on haptic simulators of their own clinical case first gave them maximum confidence to perform it on their patient. The overall experience was rated by 33.30% (n = 2) as excellent and by 66.70% (n = 4) as good. One of the comments collected at the end of the survey coincides with verbal comments made by the participants: "It was a good experience to make a previous carving on the haptics because when you carve on the patient you do it with more confidence and you have a notion of how the carving will look like."

Table 1. Students' perception of haptic simulation of a clinical case prior to patient treatment.

Aspect	n	%
Usability of milling in haptic simulator		
Useful	2	33.3
Very useful	4	66.7
Effect of practice on the haptic simulator on clinical performance		
Will facilitate it	6	100.0
Student satisfaction with the skills developed in the practice		
Satisfied	3	50.0
Very satisfied	3	50.0
Safety provided by the experience in haptics to carry out the carving process		
Safety	6	100.0
About overall experience		
Excellent	2	33.3
Good	4	66.7

DISCUSSION

In this study, 66.70% (n = 4) and 33.30% (n = 2) of the students found that haptic simulator practice was very useful and useful, respectively. These results are similar to those obtained by Fernández-Sagredo et al. (4), whose objective was to determine the perception of the usefulness of these simulators in dentistry. The authors had as participants students of the last years of the program and professionals, who performed carving practices in a haptic simulator and then a survey was applied to them, where 94% positively valued the use of this tool and considered it very useful for the development of manual skills and that they have much similarity with the real activity in terms of sensitivity.

At the same time, in the present work, it was found that 83.30% (n = 5) of participants considered that previous practice on haptic simulators provided them with maximum safety, and 16.70% (n = 1) perceived that it provided them with safety. These results coincide with those reported by Serrano et al. (5), whose pilot study with a qualitative design consisted of 10 students, who used scanned images and exported them to a haptic simulator to serve as a pre-treatment exercise for the patient. The authors obtained no concrete effects of this experience on confidence over performance; however, all participants valued positively the opportunity to perform pre-practice on a haptic simulator before performing it in the context of a real case, with the following comments being gathered: After three attempts in virtual reality I was able to easily perform a proper treatment" and 'I was able to practice precisely what I needed for this treatment' (5).

This study was limited by the small number of students who participated in the experience. At the same time, the surveys and the checklist were only validated by judges, so it is necessary to expand the study with a representative number of participants and to complement the validation of the instruments used.

CONCLUSIONS

The recurrent practice of dental preparation in the haptic simulator with the use of the image resulting from the scanning of the patient's mouth prior to the clinical procedure generates greater confidence in the student and contributes to improve his performance when administering the treatment in real cases.

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LETTER TO THE EDITOR

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Stafne's bone defect: an important finding in maxillofacial imaging

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Dear Editor:

Stafne's defect is a rare, asymptomatic jaw condition, also known as Stafne's bone cyst, Stafne's bone cavity, latent bone cyst, aberrant salivary gland defect, developmental bone defect of the mandible, idiopathic bone cavity and cortical mandible. Its etiology is uncertain; however, cases have been reported in which it occurs due to pressure from the adjacent salivary gland and in other cases due to a small connection with contiguous soft tissue that is not visualized on X-rays (1). The finding of this defect predominates in male patients between 50 and 70 years of age (2).

Radiographically, it is characterized by radiolucency, round or oval shape, unilocularity and sclerotic edges. It is classified into five types: type 0: limited to the lingual cortex; type 1: limited to the cancellous bone; type 2: reaches the buccal cortex; type 3: reaches the buccal cortex causing expansion; and type 4: without buccal cortex. This bony cavity is filled with soft glandular tissue, blood vessels, adipose and/or lymphoid tissue and nerve bundles (2-4).

The effects of Stafne's defect on adjacent structures are thinning of cancellous bone and resorption of the extended buccal cortex, according to its classification. At the same time, root resorption of contiguous teeth was reported (1).

Different imaging techniques are used for diagnosis, such as panoramic radiographs, computed tomography, cone beam computed tomography, magnetic resonance imaging (for optimal evaluation of soft tissue). Among the differential diagnoses, there are radiolucent lesions of the mandible, such as ameloblastoma, residual cyst, cyst or periapical lesions (2).

In conclusion, the identification of Stafne's defect is important, as it is considered a rare entity. In terms of imaging, it is like jaw cysts, which could lead to confusion in the diagnosis. Being a benign developmental bone defect, it does not cause any pathological changes, and surgical intervention is not necessary for treatment. However, clinical and radiographic controls are suggested every 1 or 2 years by means of a panoramic x-ray, as well as visits to the dentist (4, 5).

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LETTER TO THE EDITOR

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Impact of perceived stress in Odontology students: a university challenge

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Dear Editor:

After reading the article published in your prestigious journal, entitled "Perceived stress in dental students at a private university in Acapulco, Mexico", in the year 2023 (January-September), where it is reported that at least six out of ten students perceived high variations of stress (1). This situation has caught our attention, since it would constitute a serious impact on public health in the faculties and schools of dentistry of the different universities.

Currently, it has been reported that dental students experience considerable amounts of stress in the student period. This stress is mainly due to the demanding nature of the academic training of the dental surgeon's profession (2). It has been explained that the academic stress of students during the pandemic was due to several factors, such as the accumulation of university assignments, emotional conditions, financial factors, family issues, Internet connection, fear of testing positive for COVID-19, and lockdown (3).

The results of a systematic review contribute to the explanation that student academic stress during the pandemic was due to a variety of factors, in addition to those described above, such as symptoms of student mental disorders, physiological health problems, depression, symptoms of distress, anxiety, and poor sleep quality, which impact academic performance as well as other areas. In general, the impact of college students' stress translates into depression, burnout, inadequate mental health, and even suicidal thoughts (3).

Most of the available evidence is based on cross-sectional studies, so future longitudinal studies are needed to monitor students throughout their careers. Further research is needed to explore and test stress management interventions (2). Therefore, it is important to recognize the multiple academic activities of students —including work in some cases—, which should be a challenge for university authorities to establish preventive and promotional measures in the primary stages of student stress.

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