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El objetivo de **Acta Odontológica Latinoamericana** (AOL) es ofrecer a la comunidad científica un medio adecuado para la difusión internacional de los trabajos de investigación, realizados preferentemente en Latinoamérica, dentro del campo odontológico y áreas estrechamente relacionadas. Publicará trabajos originales de investigación básica, clínica y epidemiológica, tanto del campo biológico como del área de materiales dentales y técnicas especiales. La publicación de trabajos clínicos será considerada siempre que tengan contenido original y no sean meras presentaciones de casos o series. En principio, no se aceptarán trabajos de revisión bibliográfica, si bien los editores podrán solicitar revisiones de temas de particular interés. Las Comunicaciones Breves, dentro del área de interés de AOL, serán consideradas para su publicación. Solamente se aceptarán trabajos no publicados anteriormente, los cuales no podrán ser luego publicados en otro medio sin expreso consentimiento de los editores.

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Morphological characteristics of the facial bone wall related to the tooth position in the alveolar crest in the maxillary anterior

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ABSTRACT

The purpose of this study was to analyze whether the position of the tooth in the alveolar ridge influences the thickness of the facial bone wall and the distance between the cemento-enamel junction (CEJ) and osseous zenith (OZ).

Cone-beam computed tomography (CBCT) scans from fifty four dentate patients were included in the study (22 male and 32 female, mean age 41.5 years). The measurements taken included: (1).The Facial bone thickness at 7 different equidistant levels -measuring levels (ML 1-7) - between OZ and the root apex (A). (2) The CEJ - OZ distance. (3) Facial position of the tooth (FPT) relative to a straight line traced from mesial to distal interproximal depressions of the alveolar plate at the level of the CEJ.

The Facial bone wall thickness ranged between 0 mm and 3.8 mm, with greater values at more apical levels. Mean values were smaller than 1 mm at every level except ML7. The CEJ-OZ distance varied between 0.5 mm and 6.9 mm (mean 2.9 mm). The Mean of FPT value was 0.6 mm.

No statistically significant correlation was found between FPT and the CEJ-OZ distance. Weak negative statistically significant correlations were found between FPT and the thickness of the facial bone wall at MP1 and MP3.

Within the limits of this study, no clinically relevant correlation between FPT and facial bone thickness – CEJ-OZ distance was found.

More studies should be conducted to evaluate a greater number of teeth, especially those that may present misalignment with greater FPT values.

Key words: *Alveolar bone, Computed tomography, maxilla.*

Características morfológicas de la tabla ósea vestibular en relación a la posición dentaria en la cresta alveolar en la zona anterior del maxilar superior

RESUMEN

El objetivo del presente estudio fue analizar si la posición de la pieza dentaria en el reborde alveolar influencia el espesor de la tabla ósea vestibular y la distancia entre el limite amelo-cementario (LAC) y el cenit óseo (CO).

Tomografías computadas haz de cono (TC) de 54 pacientes dentados fueron incluidas en el estudio (22 hombres y 32 mujeres, edad promedio 41.5 años). Las medidas registradas fueron: (1) espesor de la tabla ósea vestibular en 7 diferentes niveles de medición (NM 1-7) entre CO y el ápice radicular (AR). (2) La distancia LAC-CO. (3) Posición vestibular de la pieza dentaria (PVD) en relación a una línea recta trazada desde la depresión interproximal mesial a la depresión interproximal distal de la tabla ósea a nivel del LAC.

El espesor de la tabla ósea vestibular fue 0-3.8mm, con valores mayores registrados a nivel más apical. El valor promedio fue menor a 1 mm excepto en NM7. La distancia LAC-CO varió entre 0.5 y 6.9mm (promedio 2.9mm). El promedio de PVD fue de 0.6mm.

No se encontró correlación estadísticamente significativa entre la PVD y la distancia LAC-CO. Se halló una correlación débil negativa estadísticamente significativa entre la PVD y el espesor de la tabla ósea vestibular en NM1 y NM3.

Dentro de las limitaciones de este estudio, no se encontró una correlación clínicamente significativa entre PVD y espesor de la tabla ósea vestibular – distancia LAC-CO.

Se deben llevar a cabo más estudios para evaluar un mayor número de piezas dentarias, especialmente aquellas que se encuentran desalineadas con valores PVD mayores.

Palabras clave: *Hueso alveolar, tomografía computada, maxilar.*

INTRODUCTION

Implant placement in the anterior maxilla presents a considerable challenge to clinicians because of patients' high esthetic expectations. The thickness of the facial bone wall in this region is of crucial importance for selecting the appropriate treatment approach.

A number of studies have demonstrated that dimensional changes occurs on the alveolar process following tooth extraction and that they are more

pronounced on the buccal aspect.[1-4] This difference in the healing outcome may be related to the fact that the buccal wall is thinner than its palatal counterpart.[5]

It has been suggested that immediate implant placement into extraction sockets should prevent the resorption process of the buccal bone plate[6], but this has not been supported by findings from experiments in dogs[7-9]or by clinical trials[4]. In addition, the degree of facial reduction has been shown to depend on the dimension of the buccal bone wall.[10]

It is important to consider that after implant bed preparation, the facial bone should ideally be at least 2 mm thick to ensure proper soft tissue support and prevent resorption of the facial bone wall following restoration.[11-13]

It has been suggested that for a successful esthetic outcome, the implant should be placed in an ideal three-dimensional position[14] in order to maintain adequate buccal bone[15] and tissue biotype.[16] Since correct implant placement requires proper understanding of the anatomy of the anterior region, diagnostic imaging data are essential. The thickness of the facial bone wall[17] and the position of the osseous zenith[18] are two important variables for determining the most suitable treatment approach.

Cone-beam computed tomography (CBCT) is currently the preferred tool formeasuring the thickness of bone plate.[19,20] Several studies have examined facial bone wall thickness, and although they found statistically significant results, they usually took few reference points (2 to 4) from the cemento-enamel junction (CEJ)[17,21-25], often resulting in missing information about thicknesses at more points of the tooth.

The purpose of this retrospective study was to analyze whether the facial position of the tooth in the alveolar ridge influences the thickness of the facial bone wall and the distance between the CEJ and OZ.

Our hypothesis is that the more facial the position of the tooth, the thinner the facial bone wall and the greater the CEJ-OZ distance will be.

Table 1: Total number and position of analyzed teeth.

Tooth	Canine	Lateral	Central	Total
No. teeth analyzed	68	64	71	203

Additional purposes were to describe the bone thickness on the facial aspect of the anterior maxilla at seven equidistant measuring levels (ML) and to measure the CEJ-OZ distance.

MATERIALS AND METHODS

The present study included all CBCTs from patients referred to the Department of Periodontics, University of Buenos Aires, Buenos Aires, Argentina for implant therapy from August to December 2015.

Inclusion criteria were: 1) systemically healthy patients , 2) no contraindications for performing the treatment , 3) patients having all upper front teeth in the mouth at the time of the study - 13 to 23 , 4) teeth without any injury or completely healthy in their tooth structure .

Exclusion criteria were: 1) patients with active periodontal disease or history of periodontal disease, 2) patients with bone loss related to upper anterior area or with soft tissue recession, 3) patients who had received orthodontic treatment, 4) patient tomography with scattered or distorted images, 5) teeth that had received apical surgery or with root resorption and 6) patients who had received surgical treatment of any kind in the anterior upper area.

A total 54 CBCTs met the inclusion criteria, providing a sample size of 203 teeth (Table 1).

All patients in the study accepted the clinical procedures and signed the informed consent approved by FOUBA Ethics Committee.

Radiographic image analysis

The CBCT images were analyzed on a certified monitor. Slice orientation was adjusted to pass through the center of the examined tooth perpendicular to its long axis (Fig. 1). The long axis of the tooth dictated the orientation of the vertical slice.

To perform the measurements, sagittal scans from the reconstructed data showing the entire root and the CEJ of the examined tooth were displayed, with the largest zooming factor possible for the respective images.

Image analysis was performed by image processing software. The studies were performed with a 3D cone-beam volume CT (Promax 3D, Planmeca, Finland). Images were analyzed through the Romexis Viewer 2.0.3 program (Romexis Viewer 2.0.3.R, Planmeca, Finland).

First, total root length (L)was measured from the osseous zenith (OZ) to the apex (A). This distance

was divided into seven equidistant levels for measuring the thickness of the facial bone wall at each point (measuring levels 1-7 ML1-7) (Fig. 2). CEJ-OZ distance was also measured (Fig.2).

To assess the facial position of the tooth (FPT), a straight line was determined from the facial mesial to the facial distal depressions of the interproximal alveolar crest. The shortest distance was measured between the mid-facial point of the tooth at the CEJ level and the abovementioned line(Fig. 3).

All measurements were taken by a single examiner who was blinded to the clinical findings and the follow-up of the included patients. A preliminary training and calibration session on 20 CBCT revealed an intra-class coefficient of correlation ≥ 0.75.

Statistical analysis

Quantitative variables were described by the sample size (n), minimum, medium, maximum, mean and standard deviation (SD).

The relationship between quantitative continuous variables was analyzed using the Spearman correlation test (Spearman coefficient: ρ). Pearson´s correlation test was not performed because the normality assumption was not met.

To compare quantitative variables between groups, the Kruskal-Wallis test was performed, followed by peer group comparisons when a significant result was obtained. One-way ANOVA was not performed because assumptions of normality and homogeneity

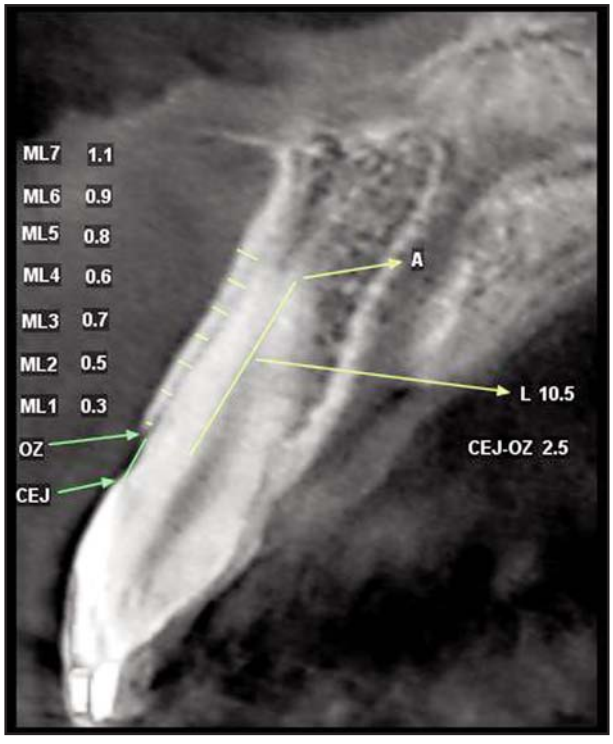

*Fig. 2: Measurement of facial bone wall thickness and CEJ-OZ distance. *CEJ= estimated position of the cemento-enamel junction; L: (OZ-A) = length of root (osseous zenith-apex); ML 1-7 = measuring levels 1-7.*

Fig. 1: Slice location in the center of the respective root, perpendicular to the alveolar ridge.

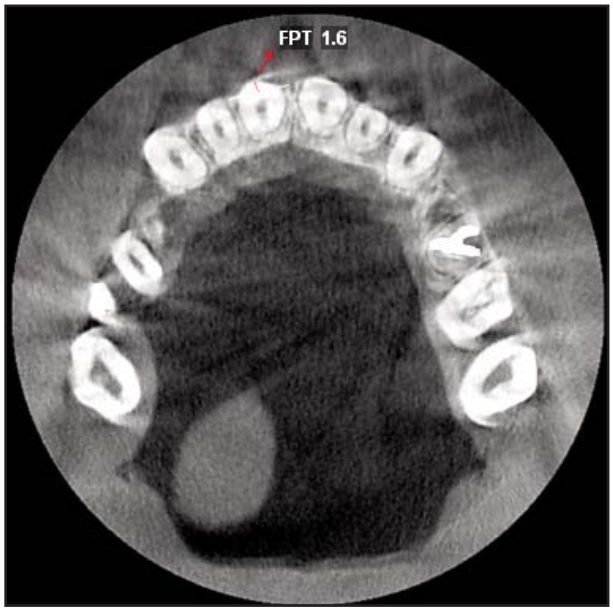

*Fig. 3: Measurement of the facial position of the tooth (FPT) *FPT=Facial position of the tooth.*

of variance were not met. The assumptions of normality and homogeneity of variance were tested by the Shapiro-Wilk test with modifications and Levene, respectively. A statistically significant result was considered when the *p*-value was less than 0.05. The 2014 version Infostatsoftware was used.[26]

RESULTS

The sample consisted of 54 subjects (22 males, 32 females) with mean age 41.5 years (range 18-65). Distribution of the analyzed teeth is presented in Table 1.

Mean thickness of facial bone wall at different levels was 1mm or less, except at ML7 (mean 1.3 mm).

Mean facial position of the tooth in the alveolar crest (FPT) was 0.6 mm (range 0.0 mm -2.7 mm). The distance between the CEJ and the OZ ranged from 0.5 mm to 6.9 mm (mean 2.9 mm) (Table 2).

Vertically, no statistically significant correlation was found between the FPT and the CEJ-OZ vertical distance (Spearman coefficient ρ: 0.132; *p* value: 0.0595).

Horizontally, weak negative statistically significant correlations were found between FPT and facial bone wall thickness at ML1 and ML3. At the other measuring levels (ML2, ML4, ML5, ML6, ML7) no statistically significant correlation was found (Table 3).

Facial bone wall thickness at ML1 and ML3 was correlated with FPT values (Fig. 4 and 5).

These values were grouped into low, medium and high categories according to the following parameters:

- Low: FPT between 0 mm and 0.3 mm.
- Medium: FPT greater than 0.3mm and equal to or smaller than 0.8 mm.
- High: FPT greater than 0.8 mm and equal to or smaller than 2.7 mm.

Facial bone wall thickness at measuring level 1 (ML1) varied significantly among the three groups of FPT (Kruskal–Wallis test: H = 6.91; df = 2; *p* = 0.03). Specifically, pair-wise comparisons showed significant differences between the groups with low and high values of FPT: facial bone thickness wall

Table 2: Thickness (mm) of the facial bone wall at seven measuring levels (ML 1-7), CEJ-OZ distance and FPT values.

	ML1	ML2	ML3	ML4	ML5	ML6	ML7	FPT	CEJ-OZ
N	203	203	203	203	203	203	203	203	203
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Median	0.8	1.0	0.8	0.8	0.6	0.8	1.3	0.6	2.9
Maximum	2.9	2.9	2.4	3.0	2.2	2.6	3.8	2.7	6.9
Mean	0.8	1.0	0.9	0.7	0.8	0.8	1.3	0.6	2.9
SD	0.4	0.5	0.5	0.5	0.7	0.5	0.7	0.5	1.1

ML1-7 = Measuring level 1 to 7;CEJ-OZ = Cemento-enamel junction - osseous zenith; FPT = Facial position of the tooth; SD = Standard deviation

Table 3: Correlation between FPT and thickness of facial bone wall (ML 1-7).

Variable 1	Variable 2	n	ρ	p-value
FPT	ML1	203	-0.168	**0.0168***
FPT	ML2	203	-0.107	0.1273
FPT	ML3	203	-0.139	**0.0475***
FPT	ML4	203	0.005	0.9471
FPT	ML5	203	0.039	0.5762
FPT	ML6	203	-0.05	0.4769
FPT	ML7	203	-0.12	0.0871

* FPT = Facial position of the tooth; ML1-7 = Measuring level 1 to 7; n = sample size; P = Spearman coefficient. *p<0.05

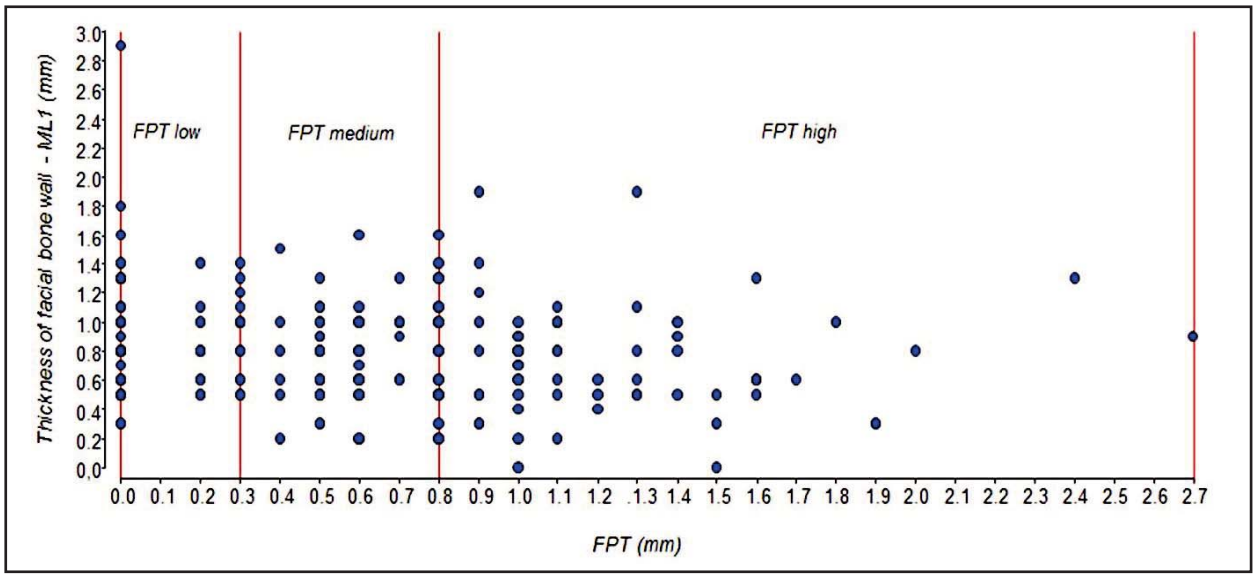

*Fig. 4: Relationship between thickness of facial bone wall at ML1 and FPT. The red vertical lines indicate the limits for the grouping of values FPT at low, medium and high. *ML1 = Measuring level 1; FPT = Facial position of the tooth.*

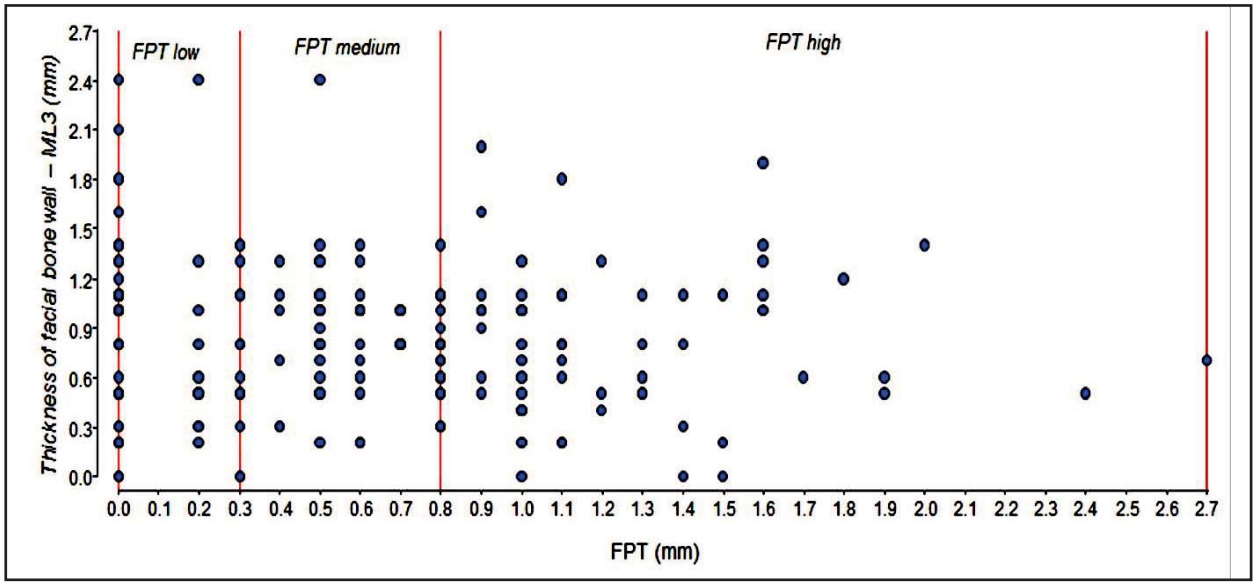

*Fig. 5: Relationship between thickness of facial bone wall at ML3 and FPT.The red vertical lines indicate the limits for the grouping of values FPT at low, medium and high. *ML3 = Measuring level 3; FPT = Facial position of the tooth.*

at ML1 was higher in the group with low FPT values (Fig.6,Table 4). No significant difference was found for facial bone wall thickness at ML3 compared among low, medium and high FPT values (Kruskal-Wallis test: H = 1.88; df = 2; p = 0.386).

DISCUSSION

Several experimental and clinical studies have shown that underlying bone structure plays a role in the establishment and maintenance of esthetic soft tissue contours[14, 27-29]. It is of clinical interest to examine the facial bone wall dimensions of teeth scheduled for extraction, especially those that are to be replaced with implants.

Data concerning the thickness of the facial bone wall in the anterior maxilla could aid in designing a more accurate treatment plan. Brauntet al.[17] evaluated the thickness of the facial bone wall in

Table 4: Comparison between ML1 and low, medium and high values of FPT.

		FPT		
		low	medium	high
ML1	N	72	70	61
	Minimum	0.3	0.2	0.0
	Q1	0.6	0.5	0.5
	Medium	0.8	0.8	0.7
	Q3	1.1	1.0	0.9
	Maximum	2.9	1.6	1.9
	Mean	0.9	0.8	0.7
	SD	0.4	0.3	0.4
*Krukskal Wallis test H = 6.91; df = 2; p = 0.03		a	ab	b

FPT = Facial position of the tooth; ML1= Measuring level 1; n= sample size; Q = Quartile; p = p-value; df = degrees of freedom
*Groups without common letters have a significant difference in pairwise comparison (p value < 0.05).

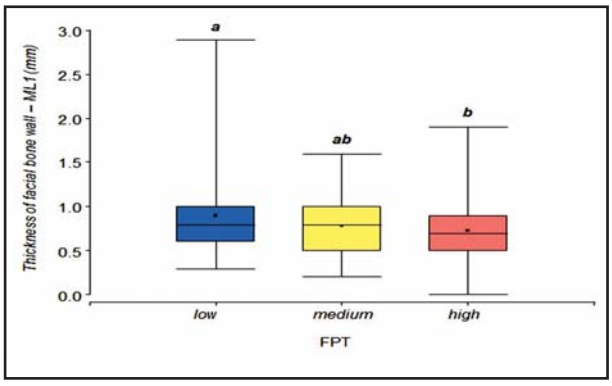

*Fig. 6: Thickness of facial bone wall at ML1 and grouped values of FPT. *ML1 =Measuring level 1; FPT =Facial position of the tooth.*

498 teeth. They concluded that the facial bone wall in the anterior maxilla was either missing or thin in roughly 90.0% of patients.

Januario et al.[21] evaluated the CEJ- facial bone crest distance and the facial bone thickness at three different levels (1, 3 and 5 mm apical to the crest), finding that it ranged from 1.6 to 3 mm, and that the facial bone wall thickness in most locations was 1 mm or less. Similar results were reported by El Nahass and Naiem,[24] who analyzed the CEJ-alveolar crest distance and the thickness of facial bone wall at 1, 2 and 4 mm to the alveolar crest, finding that 73% of the incisors had a thin facial bone wall (0.5mm-1 mm).

In the present study, CBCT images were utilized to measure facial bone wall thickness and the cementoenamel junction – osseous zenith distance. We prefer to use the term osseous zenith rather than alveolar crest. Osseous zenith was described in a previous study[18] as "the bone crest that gives support to the gingival zenith, establishing its location as the nearest portion of bone tissue underlying the gingival zenith".

Considering that the position of the tooth in the alveolar ridge could influence the thickness of the facial bone wall and the CEJ-OZ distance, the current study analyzed an important parameter that was not evaluated in previous studies[17, 21-25]: the facial position of the tooth (FPT). Moreover, the thickness of the facial bone wall was measured at seven apico-coronal levels in order to provide a more exhaustive morphological description of the bone wall, considering that previous studies did not take more than four measurements.

The results of the present study were in agreement with those reported in the literature.[17,21-25]Mean values for facial bone wall thickness were smaller than 1 mm at every level except ML7. In general, greater values were found at more apical levels. The CEJ-OZ distance ranged from 0.5 to 6.9 mm (mean 2.9 mm) and the facial position of the tooth values ranged from 0.0 to 2.7 mm (mean 0.6 mm).

Interestingly, no statistically significant correlation was found between FPT and the CEJ-OZ distance, and weak negative correlations were found between FPT and the thickness of the facial bone wall at ML1 and ML3. This could be due to the fact that all teeth examined were fairly aligned to the alveolar arch.

Within the limits of this study, although no clinically relevant correlation was found between facial position of the tooth and facial bone thickness – distance CEJ-OZ, it would seem reasonable to conclude that the facial position of the tooth could be an important variable to consider when facial bone wall thickness is evaluated.

Further studies should be conducted evaluating a greater number of teeth, especially those that may present misalignment with greater FPT values, to determine particularly thin and vulnerable bony walls and to evaluate whether a significant correlation emerges among all these parameters.

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Postural alterations as a risk factor for temporomandibular disorders

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ABSTRACT

The aims of this study were to estimate frequency and assess postural alterations as a risk factor for temporomandibular disorders (TMD).

Patients aged 10 to 15 years (N=243, mean age 12.6) seeking comprehensive dental care were analyzed according to RDC/TMD. For static postural assessment, photographs were taken and analyzed by a physiotherapist following Kendall's model. Patients were divided into: A: without TMD (n=133); B: with muscle disorders (n=61); C: with disk displacement (N=49).

No difference in age wasobserved between groups (p=0.95). Significant association was observed between muscular TMD and alterations in spinal curves, head posture, and lower limbs: OR: 3.40, 2.44 and 2.22 respectively. The most frequent types were hyperlordosis 23.30 and 32.78%; forward head posture 39.85 and 52.45%; and genu valgum 33.08 and 45.90% in A and B respectively.

Alterations in head posture, vertebral curves and lower limbs could be considered risk factors for muscular TMD. The most frequent postural alterations were lumbar hyperlordosis, forward head posture and genu valgus.

Key words: *Temporomandibular Joint Disorders, posture, child.*

Alteraciones posturales como factor de riesgo para trastornos témporomandibulares

RESUMEN

Los objetivos de este estudio fueron estimar la frecuencia y evaluar las alteraciones posturales como factor de riesgo para trastornos temporomandibulares (TTM).

Se evaluaron pacientes de 10 a 15 años (N= 243, edad media 12.6) que concurrieron para atención odontológica integral utilizando los protocolos CDI/TTM años. La evaluación postural estática, se realizó mediante fotografías analizadas por un fisioterapeuta siguiendo el modelo de Kendall. Los pacientes se dividieron en diferentes grupos según el diagnóstico: A: sin TTM (n = 133); B: con trastornos musculares (n = 61) y C: con desplazamiento del disco (n = 49).

No se observaron diferencias entre los grupos en la edad (p = 0,95). Se observó asociación significativa entre TTM muscular y alteraciones en las curvas espinales, la postura de la cabeza y los miembros inferiores: OR: 3,40, 2,44 y 2,22 respectivamente. Los tipos más frecuentes fueron hiperlordosis lumbar 23,30 y 32,78%; anteversión cefálica 39.85 y 52.45%; y genu valgum 33,08 y 45,90% en A y B, respectivamente.

Las alteraciones en la postura de la cabeza, las curvas vertebrales y los miembros inferiores podrían considerarse factores de riesgo para los TTM musculares. Las alteraciones posturales más frecuentes fueron hiperlordosis lumbar, anteversión cefálica y genu valgo.

Palabras clave: *Trastornos de la Articulación Temporomandibular, postura, niño.*

INTRODUCTION

The American Academy of Pediatric Dentistry (AAPD) has recognized the multifactorial aetiology of Temporomandibular Joint Disorders (TMJD), given the scant correlation between any given etiological factor and the onset of signs and symptoms[1]. The posture of the head and of the body as a whole plays an important role in the development of temporomandibular disorders as a result of a chronically altered craniocervical posture that leads to mandibular postural changes through mechanical/biomechanical and neuromuscular mechanisms[2,3].

Findings reported by Ishii et al. in adult patients with TMD suggest a "close relationship between stomatognathic function and the center of gravity of the body"[4]. Several studies have shown patients with TMD to have a greater forward head posture, associated with shortening of extensor muscles in the back of the neck[3]. Although a review published in 2006 suggests association between the cervical spine, the stomatognathic system, and craniofacial pain, the work was based on data from poor quality studies with low levels of evidence (3b, 4 and 5). Better studies are therefore necessary to clarify the

influence of the cervical spine on the stomatognathic system and craniofacial pain[5].
Cuccia and Caradonna recommend an interdisciplinary approach to TMD diagnosis and treatment, also involving experts in posture rehabilitation[2].
As shown by our literature review, there are reports suggesting an association between posture and TMD. Interestingly, the reviewalso showed that there are no interdisciplinary studies in children using the diagnostic criteria for TMD recommended by the IADR for epidemiological studies[6].
Thus, the aims of the present work were to estimate the frequency of postural alterations, and assess their presence as risk factor for TMD in patients aged 10 to 15 years seeking dental care at the Comprehensive Dental Clinic for Children of the Department of Dentistry for Children of the School of Dentistry, University of Buenos Aires (FOUBA).

MATERIALS AND METHODS

A descriptive, prospective, cross-sectional interdisciplinary study was conducted; the study was approved by the Ethics Committee of the FOUBA (260912-27).

Subjects

The study sample comprised boys and girls aged 10 to 15 years seeking dental care at the Comprehensive Dental Clinic for Children of the Department of Dentistry for Children in the 2012-2013 period. The participants' caregivers provided informed consent. Children with developmental disorders, medical condition, and/or neurological or psychiatric disorders were excluded.

Diagnosis of TMD

Was performed by 4 paediatric dentists who were previously calibrated in the application of the protocol for Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). The kappa index was 0.88.

Table 1: Odds Ratio with confidence intervals.

	OR B vs A	OR C vs A
Spinal curves	3.40 (1.73-6.69)	0.83 (0.43-1.61)
Head	2.44 (1.20-4.94)	0.88 (0.45-1.71)
Lowerlimbs	2.22 (1.19-4.15)	0.66 (0.33-1.31)
Anterior plane	1.37 (0.74- 2.53)	0.84 (0.43-1.64)
Lateral plane	1.10 (0.58-2.07)	0.78 (0.38-1.60)
Posterior plane	1.97 (0.80-4.86)	0.65 (0.17-2.43)

A: without TMD, B: with muscle disorders and C: with disk displacement.

Static Postural assessment

Photographs (front, back and both sides) were taken of the patients standing in a relaxed upright position in front of a grid, and analysed by the team physiotherapist following Kendall's postural types considering head position, spinal curves, lower limbs, and anterior, lateral and posterior planes[7].
The camera was placed on a height-adjustable tripod with a standard distance of 1.5 m between the camera and the subjects.
The results were recorded and analyzed using mean, standard deviation, ANOVA, OR, percentages and 95% confidence intervals.

RESULTS

The subjects were divided into three groups: A: without TMD (n=133; 12.56 ± 1.69 years); B: with muscle disorders (n=61; 12.57 ± 1.90 years); and C: with disk displacement (n=49; 12.65 ± 1.82 years). There were no differences in age among groups (p= 0.95).
The frequency of postural alterations in the 3 groups, expressed as a percentage, is shown in Fig.1, which shows that the frequency of disorders was higher in the group with muscle disorders and that the most frequent disorder was head position.
Alterations in spinal curves, head and lower limbs were significantly associated with muscular TMD: OR: 3.40 (1.73-6.69), 2.44 (1.20-4.94), and 2.22 (1.19-4.15) respectively.
No significant association was observed among the anterior, posterior and lateralplanes: OR: 1.37 (0.74- 2.53), 1.97 (0.80-4.86), 1.10 (0.58-2.07) (Table 1).
All variables had an OR <1 in group C, i.e. patients with disk displacement.
The most frequent variations in groups A and B were lumbar hyperlordosis [23.30% (16.40-31.44) and 32.78% (21.27-46.03)]in spinal curves, forward head posture [39.85% (31.44-48.71) and 52.45% (39.23-65.43)] in head posture, and genu valgus [33.08% (25.15-41.78) and 45.90% (33.03-59.18)] in lower limbs respectively (Figs.2 and 3).

DISCUSSION

To the best of our knowledge, there are no similar studies in paediatric patients in the literature. The

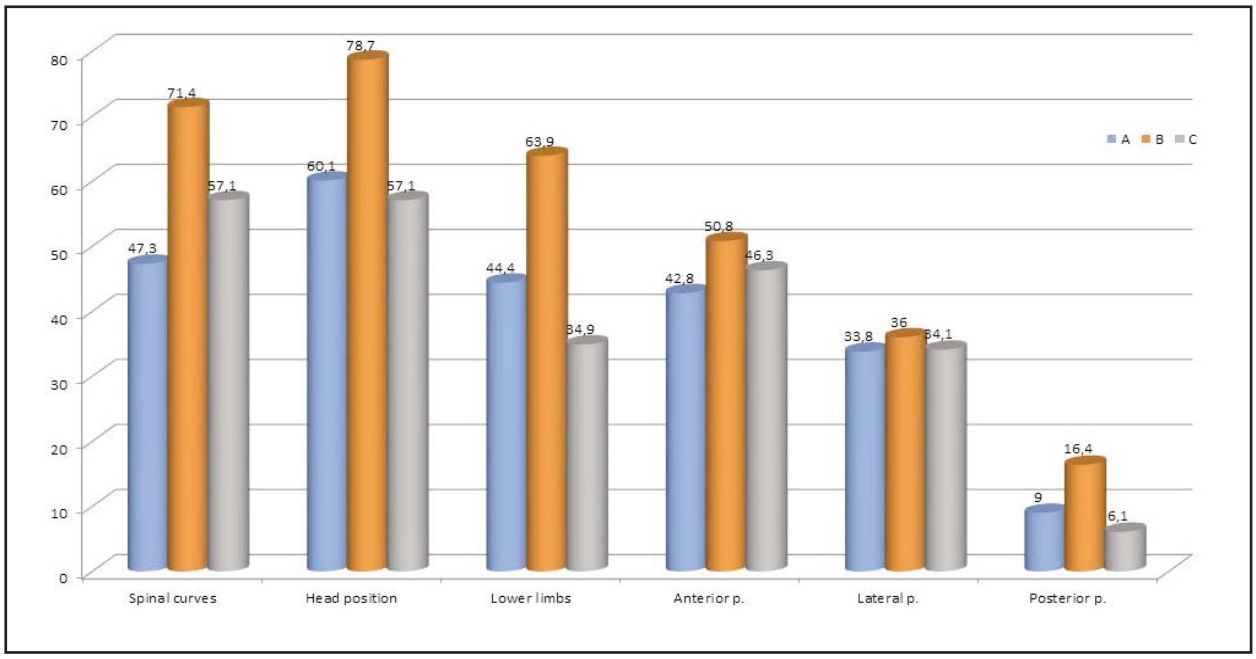

Fig. 1: Frequency of postural alterations in all groups. A: without TMD, B: with muscle disorders and C: with disk displacement.

Fig. 1: Frequency of postural alterations in all groups. A: without TMD, B: with muscle disorders and C: with disk displacement.

Fig. 3: Left knee tilted toward the midline (Genu Valgum).

methodology used to assess TMJ and posture in large samples is complex and requires the availability of adequate physical space and sufficient time to perform assessments on each child.

A similar study conducted in a sample of 30 adult patients with TMD and 20 adult patients without TMD, published in 2005, showed no significant results on account of the great dispersion of data resulting from the large number of variables used to assess posture and the small sample size[8].

There are discrepancies among reports in the literature on postural alterations in children. A recent study on children aged 9 ± 1 reported a 25.4% frequency, whereas a study conducted on11-year-old children in the Czech Republic showed 40.8% prevalence of postural disorders, with 32% corresponding to lumbar hyperlordosis[9, 10].

A systematic review seeking to evaluate the contribution of posture and psychosocial factors to the development of musculoskeletal pain in children and adolescents concluded that the duration of sitting posture may influence the experience of musculoskeletal pain[11].

Saito et al. analysed posture in adult women with and without disk displacement. Their results suggest a close association between body posture and temporomandibular disorders, and that posture assessment could be an important component in an overall approach to the prevention of TMD and treatment of patients with TMD[12].

A number of studies have used teleradiograph and/or photograph analysis[13]. A recent study conducted by Motta et al. showed alterations in head posture in adolescents with TMD, evaluated using the Helkimo Questionnaire and photogrammetry [14].

The results of the present work are in agreement with a study by Matheus et al. showing no relationship between disk displacement and cervical curvature in adults, assessed using lateral cephalograms and following RDC/TMD recommended by the IADR[15].

The present study shows a high frequency of postural alterations in children aged 10 to 15 years, in keeping with previous reported results showing an association between head posture and TMD, and with the conclusions of Saito with regard to the importance of an overall approach to the prevention and treatment of TMD. An original finding of the current study was the presence of muscular disorders and alterations in the lumbar spine and lower limbs in this age group.

CONCLUSIONS

In the present study, the most frequent types of postural alterations were lumbar hyperlordosis, forward head posture and genu valgus. In addition, our results suggest that the presence of alterations in head posture, spinal curves and lower limbs are risk factors for muscular temporomandibular disorders.

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The impact of oral health on quality of life in individuals with head and neck cancer after radiotherapy: the importance of dentistry in psychosocial issues

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ABSTRACT

The aim of this study was to assess the impact of oral health on the quality of life of patients with head and neck cancer after radiotherapy, combined or not with chemotherapy, and to compare it with that of patients with no history of neoplasia. A total 75 individuals were evaluated,including 30 with head and neck cancer after radiotherapy (study group) and 45 with no history of cancer (control group). All patients were evaluated according to World Health Organization criteria: caries activity by DMTF index, presence of periodontal disease by CPI index, edentulism index and impact of oral condition on quality of life through the OHIP-14 questionnaire. Statistically significant differences were found between the study group (SG) and the control group (CG)for caries activity conditions (p <0.001), periodontal disease (p <0.001) and missing teeth (p <0.001). These conditions had an average impact on the quality of life of cancer patients. The oral health condition of individuals with head and neck cancer deteriorates after radiotherapy, with direct impact on their quality of life.

Key words: *Quality of life, Head and neck neoplasms, Radiotherapy, Oral health.*

O impacto da condição bucal sobre a qualidade de vida de indivíduos com câncer de cabeça e pescoço após radioterapia: a importância da odontologia nos aspectos psicossociais

RESUMO

O objetivo desta pesquisa foi avaliar o impacto da saúde bucal sobre a qualidade de vida de pacientes com câncer de cabeça e pescoço após radioterapia e comparar com pacientes sem histórico de neoplasias. Foram avaliados no total 75 indivíduos, 30 indivíduos com câncer de cabeça e pescoço após radioterapia (grupo de estudo), e 45 indivíduos sem histórico de câncer (grupo controle).Todos receberam avaliação da condição bucal de acordo com critérios da Organização Mundial de Saúde: a atividade de cárie pelo índice CPOD, presença de doença periodontal pelo índice IPC, índice de edentulismo e por fim o impacto da condição bucal sobre a qualidade de vida, através do questionário OHIP-14.Quando comparados o grupo de estudo e grupo controle foi encontrada diferença estatística significativa para as condições de atividade de cárie (p<0,001), doença periodontal (p<0,001) e ausência de dentes (p<0,001). Estas condições apresentaram impacto médio sobre a qualidade de vida dos pacientes.A condição de saúde bucal de indivíduos com câncer de cabeça e pescoço depois da radioterapia é deteriorada e impacta diretamente sobre a qualidade de vida destes pacientes.

Palavras chave: *Qualidade de vida, Neoplasias de cabeça e pescoço, Radioterapia, Saúdebucal.*

Introduction

In Brazil, approximately 17.500 new cases of head and neck cancer in males and 5.340 in females were estimated in the year 2016[1]. Treatment of head and neck cancer primarily involves surgery and radiotherapy, which may or may not be combined with chemotherapy, depending on the stage of the disease[2]. The main oral complications caused by these therapies are oral mucositis, radiodermatitis, vascular lesions, tissue atrophy, dysgeusia, fibrosis of tissues and muscles, mucosal edema, soft tissue necrosis, decreased saliva flow, opportunistic infections, radiation caries and osteoradionecrosis[3-5].

The oral condition of head and neck cancer patients deteriorates due to the antitumor treatment and may compromise the masticatory function as a result of damage to tooth integrity, periodontal structures, mandibular and maxillary support, temporo-mandibular joint, masticatory musculature, facial expression and tongue, as well as their tissues, innervation and vascularization[6,7]. The diagnosis of oral conditions and oral health care should thereforebe part of multidisciplinary cancer care, with the aim of providing comprehensive treatment, including physical and emotional support to patients[5,8].

Researchers have been developing tools to assess the impact of oral health related to the quality of life of systemically compromised individuals[9]. Within this context, the World Health Organization (WHO) has included this topic among their targets for 2020[10], to provide routine patient treatment which includes both physical and psychosocial aspects related to oral problems[11-13]. To date, we have found only one article in the national and international literature relating the oral condition of individuals treated for head and neck cancer to impact onquality of life [7].

The aim of this study was to evaluate the oral health of head and neck cancer patients after radiotherapy, combined or not with chemotherapy, and compare it to that of patients without a history of cancer in order to trace the disease profile in the post-cancer phase.

MATERIALS AND METHODS

The current research was approved by the Human Ethics and Research Committee of the School of Dentistry of Bauru of the University of São Paulo (nº 703.115). A total 75 patients were divided into two groups: the study group (SG) and the control group (CG), matched according to age. The SG consisted of 30 individuals with head and neck cancer after radiotherapy, combined or not with chemotherapy. The CG consisted of 45 individuals without a history of cancer who were in good health and received dental care at the Bauru School of Dentistry - USP.

Evaluation of oral condition

Oral condition was evaluated according to the DMFT index (Decayed, Missing and Filled Teeth), community periodontal index (CPI) and evaluation of the use and need of prostheses. Data were collected by a calibrated dentist following the WHO Oral Health Surveys: Basic Methods instructions.

The individual DMFT index was calculated by adding the scores. The DMFT of the population was calculated by dividing the sum of the individual DMFT values by the number of patients examined, which provided a classification of caries activity**.**

The CPI was applied by using a blunt periodontal probe recommended by the WHO, a flat dental mirror and a disposable wooden spatula under artificial light. Presence of biofilm, dental calculus and periodontal pockets was recorded for the buccal and lingual surfaces of six index teeth: right upper first molar (16), right upper central incisor (11), left upper first molar (26), lower left first molar (36), lower left central incisor (31) and the first lower right molar (46).

The evaluation of edentulism followed WHO guidelines for epidemiological surveys. It considered type and site of prosthesis, mandibular or maxillary, according to the prosthetic spaces corresponding to the missing teeth observed in the physical examination.

Evaluation of the impact of oral health on quality of life

The assessment of the impact of oral health on quality of life was carried out using the Oral Health Impact Profile (OHIP-14), composed of 14 questions proposed by Slade (1997)[14]and validated in the Portuguese language by Oliveira and Nadanovsky (2005)[15]. The OHIP-14 analyzes the impact on quality of life by the dimensions of oral health, which are the following: functional limitation, physical pain, psychological discomfort, physical incapacity, psychological incapacity, social incapacity and disability, according to the weights for the answers obtained.

The response scale (0 = never, 1 = hardly ever, 2 = sometimes, 3 = almost always, 4 = always) was multiplied by the corresponding weight to calculate total impact. Impact was considered weak 0 - 1.33, average 1.33 -2.68, and strong > 2.68. Overall impact was given by the sum of the impact of the dimensions, and considered weak for scores of less than 9.33, medium 9.33 -18.66 and strong > 18.66.

Statistical analysis

The Kruskal-Wallis test was used for all multiple comparison procedures by the Dunn method, considered significant when $p < 0.05$.

RESULTS

Table 1 shows the demographics, including age, sex, type and location of the neoplasia, submitted to radiotherapy combined or not with chemotherapy, and type of radiotherapy.

In SG, DMFT ranged from 17 to 28 with a median of 24, while in CG it ranged from 12 to 32 with a median of 18. The difference between SG and CG was statistically significant ($p < 0.001$) (Table 2**).**

Table 1: Demographic data related to gender, type and location of cancer, type of radiotherapy and chemotherapy as combined therapy of SG (n = 30).

Genre	Men (25)
	Women (5)
Typeofneoplasm	CEC-Squamous cell carcinoma (27)
	Cystic Adenoid Carcinoma (1)
	Invasive Basal Cell Carcinoma (1)
	Mucoepidermoid Carcinoma (1)
Location of the neoplasm in the head and neck region	Amygdala; Tonsil palate (7)
	Tongue (4)
	Buccal floor (4)
	Gum (3)
	Nasopharynx (3)
	Larynx (3)
	Cheek mucosa (2)
	Vocal cords (1)
	Adenoid (1)
	Lips (1)
	Hypophysis (1)
Typeofradiotherapy	Conventional (22)
	**IMRT (8)
Combined chemotherapy for antineoplastic treatment	Yes (17)
	No (13)

*IMRT- Intensity-modulated radiotherapy

Table 2: Data related to age, ** DMFT index and ** CPI index.

Group	n	Age			DMFT				CPI			
		Minimum	Maximum	Median	Minimum	Maximum	Median	P-value	Minimum	Maximum	Median	P-value
Study	30	35	79	61	16	28	24	*p=0.001	0	4	2	*p<0,001
Control	45	35	78	52	12	32	18		0	1	0	

* Significant statistical difference (p> 0.05) (n = 100).
** DMFT-Index of decayed, missing and filled teeth; CPI- Community Periodontal Index

Periodontal disease was present in 29 of the 30 individuals inthe SG (96.66%). In SG, the CPI index ranged from 0 to 4 with a median of 2, while in CG it ranged from 0 to 1 with a median of 0. The difference between SG and CG was statistically significant (p <0.001) (Table 2).

With regard to edentulism, 96.7% of the SG and 77.8% of the CG needed oral rehabilitation with some type of dental prosthesis. The WHO scores edentulism provided the following results: the use of an upper prosthesis with median SG (2, 1stquartile = 0 and 3rd quartile = 4.5), and in the median CG (0; 1st quartile = 0 and 3rd quartile = 0.5) (p <0.001). Use of lower prosthesis with median SG (0, 1st quartile = 0 and 3rdquartile = 0.75), and median CG (0, 1stand 3rdquartiles = 0), no statistical difference was found.

Need for upper prosthesis, with median SG (0, 1st quartile = 0 and 3rd quartile = 1) and median CG (1, 1st quartile = 0 and 3rd quartile = 2) (p <0.001). Finally, the need for lower prosthesis with median SG (2; 1st quartile = 2 and 3rd quartile = 2) and median CG (0; 1st quartile = 0 and 3rd quartile = 1) (p <0.001). Values for impact of oral condition on quality of life in the SG were 4.67 to12.94, with a median of 9.62, indicating medium impact. In contrast, the values in the CG were 0 to6.42, with median of 1.48, indicating weak impact. The impact of oral condition on quality of life differed significantly between SG and CG (p <0.001).

DISCUSSION

Two thirds of head and neck cancer patients have localized or regionally advanced disease, and although there is controversy regarding the best treatment, they are usually treated with surgery, and radiotherapy, which may or may not be combined with chemotherapy (multimodal treatment). These therapies have adverse effects on oral health, especially if oral diseases such as caries and periodontal disease are already present, and invariably compromise quality of life[2].

Among the most frequent complications that compromise patient quality of life are reduction or absence of salivary flow, radiation cavities, periodontitis, odynophagia, dysphagia, pain and speech difficulties[17], which may compromise the patient's social, nutritional and global health and quality of life as a whole.

The DMFT index estimated by the WHO is 1.2 to 2.6, the current value for the Brazilian population being 2.1[18]. The present study reveals a noticeable discrepancy between the national index and the indices for the population that received radiation for the head and neck region The incidence found in the literature was similar to that found in this study (DMFT = 24 / median), which is a high index, considering that the individuals in these studies ended radiotherapy over 6 months ago[18-20]. The literature includes studies conducted on patients of specific ethnicities, but in all of them, time after treatment seems to be a determining factor for the effects of antineoplastic therapies on caries activity, which may be greater, especially when it is induced by radiotherapy and chemotherapy[18-20].

The incidence of periodontal disease in post-antineoplastic therapy head and neck cancer patients is poorly described in the literature, but it is about 64% to 78% [20,21]. Our study found an incidence of 96.6%, and a significant difference in CPI between SG and CG (p <0.001), revealing that periodontal disease is also a matter of concern in this group of patients, mainly due to infection control and evolution to tooth loss. Tooth loss is common in the evolution of periodontal disease because it is difficult to control[22]. Many studies mention the relevance of performing periodontal disease prevention prior to treatment with radiotherapy / chemotherapy, because periodontal disease is more difficult to control after antineoplastic therapies[5,20,22,23].

Radiotherapy increases the risk of osteoradionecrosis, especially when the dose exceeds 60 Gy and is associated with local trauma such as dental extractions, and infections such as uncontrolled periodontal disease, and compromised by hyposalivation[24,25].

Edentulism in individuals treated for head and neck cancer has not yet been evaluated, according to a review of the literature in English and Portuguese. Although the absence of teeth is described in oral rehabilitation studies after radiotherapy, the incidence of edentulism is not reported. Our study found significant differences between SG and CG (p <0.001) with a high incidence of oral rehabilitation (46.6%), mainly related to the need for prostheses in the maxillary and mandibular arches. These results lead us to reflect on the limitations related to missing teeth, often prior to radiotherapy and surgery. With regard to the evolution of radiation cavities and periodontal disease as a consequence of radiotherapy, oral rehabilitation options are often denied by dentists because of the limited therapeutic options. Prosthetic rehabilitation and/or dental implants are still questioned in the literature; however, it is mentioned that having received radiotherapy is not an impediment for rehabilitation.It is clear that it is necessary to establish strict criteria regarding the type, dose and area of radiotherapy[26]in order to achieve adequate oral rehabilitation forthe patient. Edentulism itself impacts quality of life, leading to functional, aesthetic, social and psychological changes.

The psychosocial aspects related to oral problems have been of interest to the WHO since the 1980s, when the consequences of diseases in people's daily

lives were classified, and since 2000 these aspects have been related to dentistry. In this context, the OHIP-14 questionnaire provides answers related to the dimensions of physical and psychosocial limitations that can diagnose the impact of oral health on quality of life. The literature contains only one report of research in the field of head and neck cancer in which the Oral Health Related to Quality of Life (OHRQoL) questionnaire was used to associate oral condition and quality of life after radiotherapy[7], and none using the OHIP-14. In the current study, the OHIP-14 questionnaire showed that the impact of oral health on quality of life in SG was average (9.62), and differed significantly from CG (1.48) ($p < 0.001$). These results reveal a clear diagnosis and an alert forthe need for care in the return to and maintenance of oral health of individuals who under go radiotherapy in the head and neck region, as well as the need for further research on the relationship between oral status and quality of life.

Acute and late complications of antineoplastic therapy such as oral mucositis, dysgeusia, radiation caries, periodontal disease and osteoradionecrosis of the maxilla[5] have a relevant effect on the patient, reducing his/herquality of life. Clearly these complications can be appropriately reduced and controlled with prior dental treatment and proper conservation.

Considering the results of this study, it is important to reflect on the biological limits of oral health maintenance and oral rehabilitation of patients who under go antineoplastic treatment, especially radiotherapy to treat head and neck cancer. It is also important to understand that the multidisciplinary team, including dentists, should be committed not only to curing cancer, but also to returning quality of life to patients, provided that everyone understands the limitations and the possibilities of applying consolidated techniques to return these patients to oral health.

CONCLUSIONS

Caries activity, periodontal disease index and incidence of edentulism are high in individuals undergoing radiotherapy to treat head and neck cancer. These oral conditions significantly and negatively compromise the quality of life of these patients.

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Evaluation of an experimental remineralizing agent for repairing enamel surfaces

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ABSTRACT
The best material for repairing enamel surface defects is one very similar to the original enamel and which interacts with natural remineralization mechanisms. It does not repair extensive damage, so in order to fill large defects,external help is required using phosphocalcic ceramic composites that activate salivary remineralization efficiently though on smaller in scale. Effective adhesion of the repair may depend on the amount of aqueous fluids present in the enamel, which apparently enable nucleation and growth of new minerals to ensure adhesion and stability. The amount of fluids is governed by osmotic pressure. This study evaluated the influence of two osmotic pressure values of isotonic and hypotonic saliva and two modified remineralizing agent compositions: combinations of "conditioner" and "remineralizing agent" in proportions of 90%: 10% (A) and 50%: 50%(B), on filling artificial cracks. Results were evaluated by profilometer, stereomicroscope and confocal laser microscope. A 22 factorial design and a logistic model for statistical analysis were used. Only the composition of the mineralizing agent had a significant effect on efficiency in repairing defects. Compositions A and B both repaired dental enamel defects, but composition B presented higher levels of repair and more compact deposits as observed under stereomicroscope.

Key words: *Dental enamel, biomaterials, calcium phosphates, tooth remineralization.*

Evaluación de un agente remineralizante experimental reparador de superficie de esmalte

RESUMEN
El mejor material para reparar defectos superficiales del esmalte es uno muy similar al original y que este interactúe con los mecanismos naturales de remineralización. Este no arregla daños extensos por lo que se requiere de una ayuda externa para rellenar defectos grandes con un material que active la remineralización salivar que sea eficiente pero de menor alcance. Para esto se emplearon cerámicas compuestas principalmente fosfocálcicas. La adhesión efectiva de la reparación puede depender de la cantidad de fluidos acuosos existentes en la porosidad del esmalte pues aparentemente permiten la nucleación y crecimiento de nuevos minerales para asegurar adhesión y estabilidad. La cantidad de fluidos está gobernada por la presión osmótica. En este estudio se evaluó la influencia que tienen dos valores de presión osmótica de la saliva isotónica y hipotónica y dos composiciones de agente remineralizante modificado: condicionador y agente remineralizante en composiciones de 90%/10% (A) y 50%/50%(B) respectivamente, sobre el llenado de grietas artificiales por perfilometría, estereomicroscopio y microscopía confocal láser. Se trabajó con un diseño factorial 22 y tratamiento estadístico: modelo logístico. Solamente la composición de la sustancia remineralizante tuvo efecto significativo en la eficiencia para reparar defectos. La composición tiene un efecto reparador sobre los defectos del esmalte dental en sus dos composiciones, no obstante, la composición 50%/50% presenta niveles más altos de reparación y forma depósitos que al estereomicroscopio se observan más compactos.

Palabras Clave: *Esmalte dental; Materiales biocompatibles; Fosfatos de calcio; Remineralización dental.*

INTRODUCTION

Dental enamel is a bioceramic composite which consists of 96% minerals and 4% organic material (proteins) and water [1,2]. Because it lacks cells, rather than being considered a tissue, it is considered to be a highly mineralized extracellular substance incapable of regenerating itself when it suffers attacks [1,3].

Enamel may suffer superficial defects such as infractions in response to mechanical over-exertion or extreme conditions to which it is subjected in the oral cavity. To treat such injuries, reparative techniques have been used,[4]including restorative materials with different retention mechanisms[5] such as amalgam, metal alloys, ceramics, and composite

resins combined with dental adhesives[6,7], all of which have provided acceptable solutions for preserving tooth integrity. However, small, shallow lesions that are thicker than 50µm[8] do not warrant the use of preparations that destroy even more dental structure and lead to the use of restorations that form interfaces with the dental substrate and facilitate microfiltration and tooth decay. Knowledge of the composition of enamel and biomaterials has driven the search for more conservative solutions to the problem of loss in tooth integrity.

Different bioceramics have been proposed for clinical use in view of their biocompatibility, bioactivity and dissolution rates. Supersaturated solutions of calcium, phosphate and magnesium ions[9,10], fluorapatite-gelatin[11], electrodeposition[12], apatite[13] and fluorapatite cement have been studied and proposed for tooth enamel repair[14]. Many studies of these materials are currently still in the *in vitro* phase, so their effects in clinical conditions are as yet unknown.

Agents containing mainly calcium phosphates, such as a "modified conditioner" and a "remineralizing agent", which have been tested *in vitro* on enamel crack defects, decreased the size and number of these defects without creating an interface. The "modified conditioner" produced many adherent deposits of irregular appearance and different color of the enamel[15,16], while the "remineralizing agent" created less abundant deposits and had a clear appearance and regular pattern[17,18]. Experiments were conducted with each agent at two different time points on moist, freshly extracted teeth. The agents were then tested on dry teeth one year after extraction. Better results were obtained with wet teeth than with dry teeth. As a general result of the experiments, it was suggested that the difference in the results was due to the moisture level of the specimens [15-18].

The seemingly complementary properties of the two ceramics - "remineralizing agent" and "modified conditioner",in addition to their ease of handling and the low cost of their components, led to the proposal of combining them as a third substance, Modified Remineralizing Agent (MRA), which combines properties of the original components regarding volume, regularity and color of the deposits formed. Different proportions of the two ceramics in the combination yield different results, and must therefore be defined.Two compositions were selected and called MRA_1 (90% remineralizing agent and 10%modified conditioner) and MRA_2 (50% and 50%). The effects of these two MRA compositions and two moisture contents on the efficiency of the repair process on groove-shaped enamel defects (more or less deep straight cuts) in tooth enamel were studied. The aim of these experiments was to determine whether the level of enamel repair depended on saliva composition (osmotic pressure), modified remineralizing agent (MRA) composition, or the interaction between them. This study seeks to advance the understanding of the behavior of the material under controlled laboratory conditions.

MATERIALS AND METHODS

Sample collection

With prior approval from the Ethics Committee of the School of Dentistry at Universidad Nacional de Colombia (CIE-00017-11) and signed informed consent from the donor patients, aged 15 to 45 years, 104 human teeth without hypoplasia, fractures, endodontic treatment, rehabilitation, bleaching or vestibular restorations were collected.

Sample pre-treatment

Following the Tooth Bank standards of the School of Dentistry at Universidad Nacional de Colombia, the teeth were transported, cleaned, disinfected and preservaded in 0.5% chloramine-T at 4°C[19]. The middle third of the vestibular surface was established as the study zone, and delimited by four marks in a square made with a round ¼ carbide bur, 17839-SSWHITE, with a high-speed NSK (at 200,000 rpm) handpiece. A cutter was used to create groove-shaped enamel defects in mesiodistal direction, 200 µm to 400 µm deep and 100 µm to 260 µm wide. The profiles and dimensions of the defects were established using a Veeco profilometer, Dektak model; a Nikon SMZ 800 C-DS stereomicroscope and an LSM 700/Zeiss confocal laser microscope (Fig.1).

Following the experimental design in a symmetrical 2^2 factorial arrangement, there were two controlled factors with two levels each: Compositions of the modified remineralizing agent $MRA_1$and MRA_2, and isotonic (IS) and hypotonic (HS)saliva. The two different MRA compositions contained different percentages of preexisting components (products

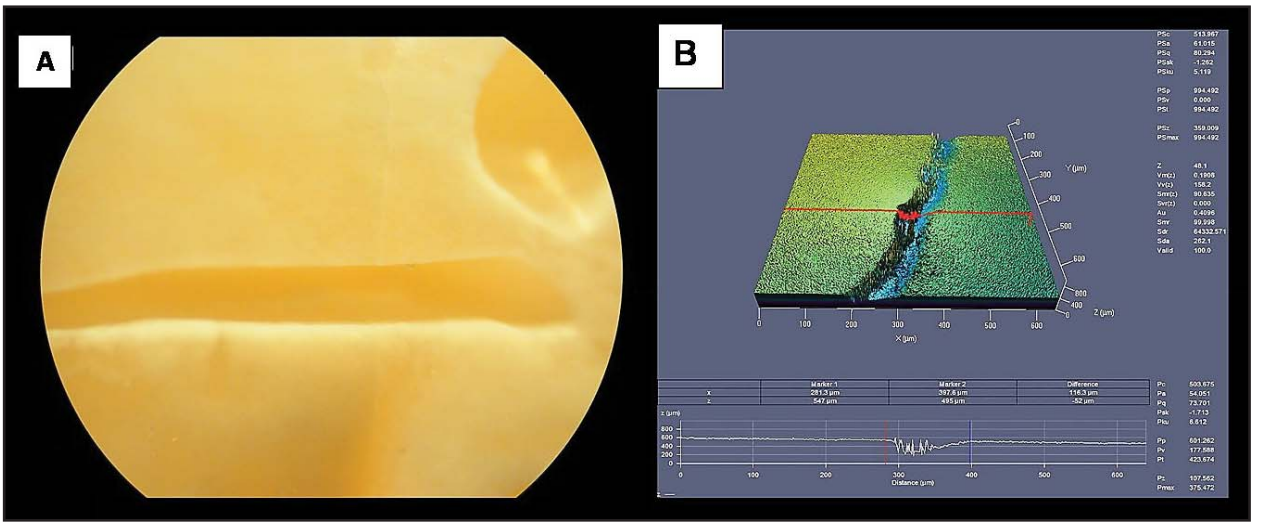

Fig. 1: A and B Groove-shaped enamel defects200-400 µm deep and 100- 260 µm wide were created in the mesiodistal direction. Defect profiles and dimensions were established using stereomicroscope and confocal laser microscope.

of the ceramics laboratory, Department of Chemistry, Universidad Nacional de Colombia) and saliva composition was established by varying its osmotic pressure. Specimens were randomly divided into four paired groups of 26 samples, labeled as MRA_1-IS, MRA_1-HS, MRA_2-IS and MRA_2-HS, where IS and HS are isotonic and hypotonic saliva respectively, according to the corresponding combinations of treatment effects.

Sample treatment

To evaluate the effect of the osmotic pressure of the moist environment on the outcome of filling defects, teeth were submerged in artificial isotonic (IS) or hypotonic (HS) saliva for two weeks, then washed with a toothbrush under running water, after which they were subjected to surface abrasion with number 1000 silicon carbide sandpaper, washed in water with a soft tooth brush and cleaned with 2-propanol to remove impurities. To evaluate the efficiency of the MRA compositions, MRA_1 and MRA_2 were applied to randomly selected teeth for six hours, with the treatment area isolated from the environment. After the treatment time, the teeth were washed again with a brush and running water to remove any non-adherent deposited material. Teeth were observed and photographed via stereo-microscopy at 4X magnification. A previously calibrated observer, with Kappa 1 intra-examiner reproducibility, assessed treatment results under a stereomicroscope by classifying the filling of defects into three levels: **Low**, when part of the floor of the created defect was visible (not covered with filling material); **Medium**, when the filling did not reach one or all of the external boundaries of the defect, but the floor was not visible; and **High**, when the filling level of the defect reached or exceeded the external boundaries.

Statistical analysis

Because the response variable was binary, a logistic model was used to identify the effect of treatments. Different analyses were performed using generalized linear models to determine the effects of saliva composition (osmotic pressure) and composition (MRA_1 or MRA_2) on the level of tooth repair. The chosen statistical hypotheses of interest (MRA composition, saliva, and their interaction) were considered significant when $p< 0.05$. Goodness of fit was verified with statistical procedures based on properties of the chi-squared distribution, and the quality of fit of the proposed model was validated through a graphic review of Pearson and Deviance residuals. The information obtained was processed using R software, version 11.1.

RESULTS

All treated teeth presented some degree of repair, and only one tooth presented a low level of repair. This tooth was eliminated, and only medium and high levels of repair were considered; thus, the analysis focused on modeling the probability that

the tooth would have a high level of repair. A greater number of teeth was found to have a high level of repair (76% of the total). The proportion of teeth with medium and high level of repair was the same for each treatment; however, teeth treated with composition MRA_2 (50%-50%) seemed to attain a higher degree of repair (Table 1).

Fitting the logistic model to the interaction showed no statistical significance ($p = 0.43$), meaning that when salivary osmotic pressure varied, whether or not the MRA composition was constant, there was no change in the level of repair.Thus, the final definitive study model additively incorporated the effects of saliva composition and remineralizing agent only.

For the model with interaction, changing the osmotic pressure did not statistically influence the level of repair, given that the $p=0.82$ value is very high. In contrast, significant differences were detected for MRA ($p< 0.05$), as shown in Table 2.

With regard to differences in the effects achieved with the two MRA compositions, MRA_2 was found to be more likely to achieve a high level of repair. Using the logistic model, the probability of repair for each treatment is listed in Table 3. Best outcomes were achieved with hypotonic saliva, with 0.85 probability.

The p-value associated with Pearson's chi-squared statistic was 0.28, suggesting a good fit of the model and validating the conclusions reached above. Diagnosis of the model residuals shows no unsuitability problems for the adjusted model.

All teeth showed some degree of defect coverage. Fig.2 shows characteristics of enamel defect fillings under a stereomicroscope, a confocal laser microscope and scanning electron microscopy (SEM). Composition MRA_2 provided more regular and dense filling (Fig. 3A) than MRA_1 (Fig. 3B). Observation of the agent deposited on the enamel defects revealed spherical particles (Fig. 3C) and irregular elongated shapes (Fig. 3D).

Table 1: Number of teeth according to repair level and treatment. Specimens with medium or high levels of repair.

	Number of teeth according to repair level	
Treatment	**Medium**	**High**
MRA1-IS	9	17
MRA1-HS	7	18
MRA2-IS	3	23
MRA2-HS	5	21
Total	24	79

MRA1-IS: Modified Remineralizing Agent (1,2) – isotonic saliva
MRA2-HS: Modified Remineralizing Agent (1,2) – hypotonic saliva

DISCUSSION

Most studies in the literature report promising results regarding the remineralizing capacity of the agents proposed for early management of artificial cavities[9,20-25]. Unlike the previous studies, but following similar principles, this study sought to test the repair capacity of MRA as compositions MRA_1 and MRA_2 on mechanically created defects, toward the ultimate goal of creating an efficient material that can be used in clinically visible lesions.

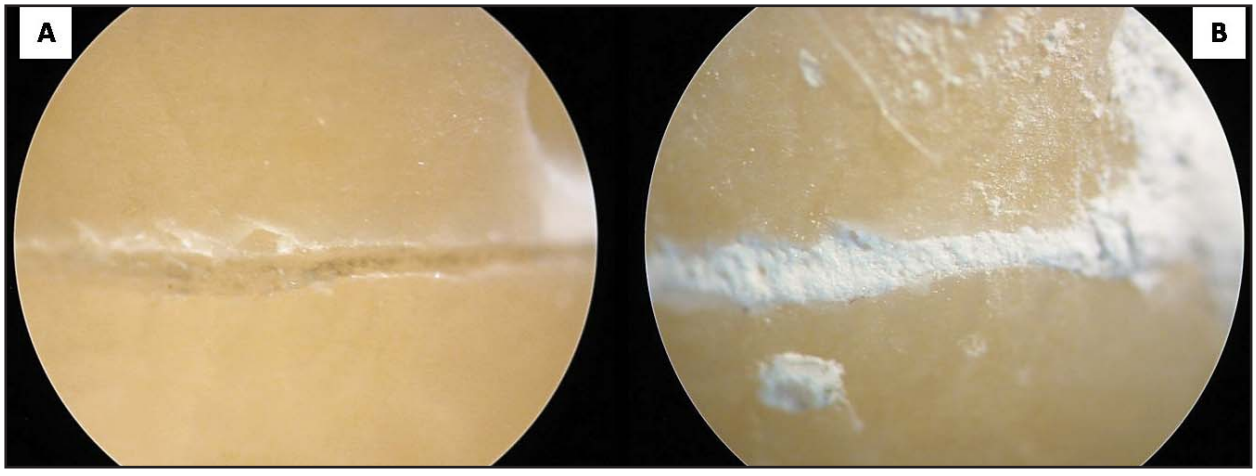

Fig. 2: A and B show characteristics of enamel defect before and after filling with MRS under a stereomicroscope.

Table 2: Statistical analysis of the model.

Variable	Statistic	Degrees of freedom	p-value
Saliva composition (osmotic pressure)	0.0549	1	0.82
Remineralizing agent composition	43.437	1	0.04*
OP Interaction and Composition		1	0.428

OP: osmotic pressure

Table 3: Logistic Model. Probability of repair for each treatment.

Probability of repair	MRA1-IS	MRA1-HS	MRA2-IS	MRA2-HS
High repair probability	0.685	0.661	0.839	0.853
Medium repair probability	0.315	0.339	0.161	0.147

MRA1-IS: Modified Remineralizing Agent (1,2) – isotonic saliva
MRA2-HS: Modified Remineralizing Agent (1,2) – hypotonicsaliva

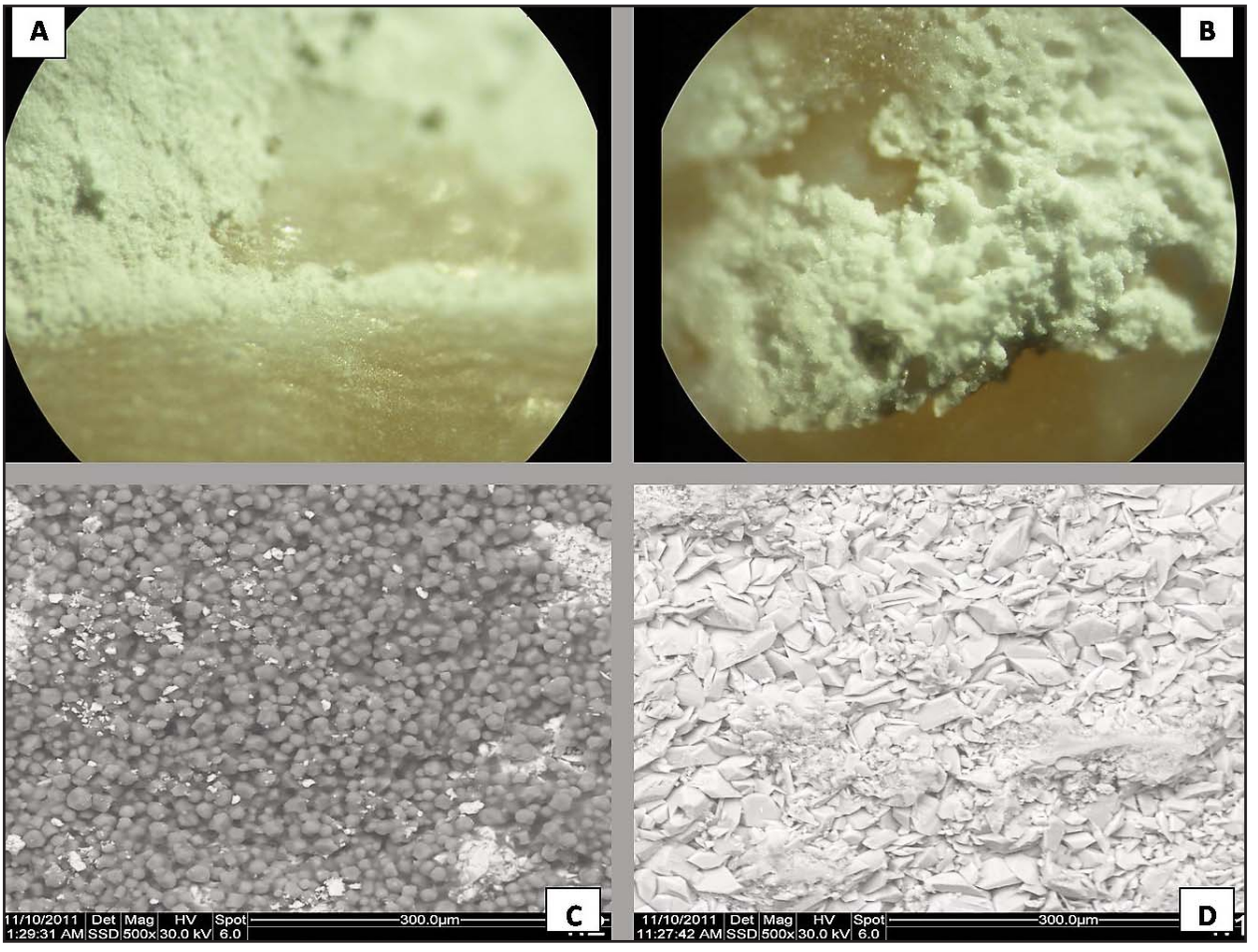

Fig. 3: A, MRA2: more regular and dense filling was observed. B, MRA1:irregular and no dense filling. Agent deposited on the enamel defects: C, spherical particles and D, irregular, elongated shapes.

The agent tested in this study is composed of constitutive ions from enamel, mainly phosphates and calcium, enabling it to bind chemically to the enamel substrate, based on the principle of secondary nucleation. Approximate particle size is 5-15µm, determined by SEM at 500x, and particles have irregular, elongated, spherical shapes that may correspond to amorphous phases or different degrees of crystallinity. Because ceramics are more durable than polymers, which hydrolyze and degrade over time, it is advantageous to use purely ceramic compositions. Additionally, because the ceramics are mainly phosphocalcic, they play an active role in remineralization with natural saliva and may simultaneously lead to remodeling of the structure and surface porosity according to the Ostwald ripening principle.

Based on preliminary tests, an application time of six hours was established, which was the shortest time that allowed abundant formation of adhesive deposits within and around the defects.In 2001, Eisenburger et al. produced erosions with citric acid using the same time period andobserved decreased lesion depth after storage in artificial saliva and exposure to ultrasonic cleaning, suggesting that strong bonds were achieved between the dental substrate and the applied material[26]. This is desirablefor agents used for repairing the surface of hard dental tissue. Li et al. 2008 observed a weak bond when using blocks of hydroxyapatite nanoparticles, perhaps due to differences in size and development time of the material formed compared to those from original hydroxyapatite enamel[3]. Our study tested whether the agent was easily removed by mechanic brushing with moderate pressure under running tap water for five seconds, after which the permanence of the material deposited on the tooth surface was observed, particularly within the defects. This permanence could be explained based on nucleation principles, with the defect area having high binding energy compared to the surfaces.

Many studies have used different methods to demonstrate the repair capacity of biomimetic agents[21, 24, 27, 28] such as supersaturated ionic solutions that favor the precipitation of calcium and phosphate ions[29]. These solutions appear to be more efficient than saliva itself, possibly due to the organic composition of saliva having an inhibitory effect on crystal nucleation and growth[30].

Immersing teeth with artificial cavities in synthetic hydroxyapatite solution with a calcium/phosphate ratio of 1.63 showed repair capacity not only in the enamel surface but also in the depth of the lesion, unlike the same treatment with human saliva (with or without fluoride), in which the effect was limited to the surface[31]. Studies using toothpaste with hydroxyapatite-carbonated nanocrystals observed formation of a coating on the tooth enamel, with inferior crystallinity to that of the enamel but adequate capacity to repair the surface defects described[20]. Using natural caries lesions, Wei et al.[14] tested a fluorapatite cement as a repair material for tooth enamel cavities previously acid-etched with 17% phosphoric acid for 30 minutes. They achieved a strong bond to the enamel with no apparent gap and the structural composition of apatite.

Other studies seeking the same repair effects achieved with mentioned agents and using ionic agents applied on superficial cracked tooth enamel, observed the formation of adhesive deposits that completely or partially covered these defects, with effectiveness that appeared to depend on the moisture used[15-18]. Our study mixed remineralizing and conditioning agents in two different proportions to prepare compositions MRA_1 and MRA_2,which were placed in direct contact with groove-shaped surface defects of teeth. Both these compositions provided mostly high filling levels. Although no statistically significant difference was observed between treatments in relation to reparative capacity, teeth treated with composition MRA_2 (50% and 50%) had the highest level of defect repair. This could be because the agent is composed of two precursor agents in equal proportions, which may increase the potential of both: the filling volume of the restorative material and the fineness, low volume and substrate-binding characteristics of the conditioning agent, which had been pretested as a bracket-bonding material. Such combined qualities couldalso explain why this composition has an aesthetically acceptable appearance, perhaps because the fine particles cover spaces that are left bycompositions of larger volume.

The fact that there does not appear to be a significant effect of the aqueous medium to which specimens were previously subjected on the restorative capacity of MRA_1 and MRA_2 compositions in this study may indicate thatthe saliva

compositions used here might not be different enough to establish their influence.

The agent deposited on the tooth surface is chalk-white in color and has a porous appearance compared to tooth enamel. The white color is due to the fact that the agents applied are colorless crystalline materials which produce the full range of visible colors due to the multiple angles at which they diffract light, perceived together by the eye as white. Its difference in color of human enamel is due to the orientation, size and shape of the crystals and to the fact that spaces between enamel prisms are filled with organic material and the glass phase of calcium phosphate crystals, which increase translucency, while in the repair area there are unfilled pores. Differences may also be related to the short duration of the mineral formation process compared to the biomineralization of hard tissues, which does not allow sufficient ripening to achieve a higher degree of crystallinity. Further studies should consider filling pores in the restored area with biomimetic glassy material which in addition to decreasing porosity, may improve appearance and color.

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Dental skeletal effects of the metallic splinted Herbst appliance after growth spurt: a lateral oblique cephalometric assessment

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ABSTRACT

The aim of this study was to evaluate dental and skeletal changes induced by the use of Herbst appliance compared to natural growth in young adults with Class II division 1 malocclusion with mandibular retrusion, by means of lateral oblique radiographs. Forty-six subjects, 14 - 18 years old, after pubertal growth peak, with Class II division 1 malocclusion were assessed. Subjects were divided into two groups: the Experimental group included 23 subjects treated with Metallic Splinted Herbst and the Control group included 23 subjects followed without treatment. The Experimental and Control groups were paired by sex and chronological age. Oblique lateral cephalometric radiographs of the left and the right side of the mandible before treatment (T1) and after 8 months' treatment (T2) were used to evaluate dental and skeletal changes. Statistical analysis was performed with Intra Class Correlation and Student t-test, according to the study hypothesis. The results showed that the appliance corrected the Class II relationship in an 8-month period by mesial tipping movement of lower permanent first molars. It had little influence on mandibular structure and mandibular length and no influence on maxillary structure and upper molar. To conclude, late treatment of Class II malocclusion with the Herbst appliance was accomplished by means of dentoalveolar changes. These findings suggest that this type of treatment can be used in patients after growth has ceased because the results do not depend upon skeletal changes.

Key words: *Angle Class II Malocclusion; Orthodontic Appliances, Activator; Orthodontics.*

Efeitos dentoesqueléticos do aparelho splint metálico de Herbst apóssurto de crescimento: estudo com telerradiografias em 45°

RESUMO

O objetivo é avaliar mudanças dento esqueléticas induzidas pelo uso do aparelho de Herbst considerando crescimento natural através da telerradiografia cefalométrica em 45o em adultos jovens com Classe II divisão 1 e retrusão mandibular. Uma amostra de 46 indivíduos com idade entre 14 a 18 anos, após surto de crescimento pubertário, Classe II divisão 1 foram avaliados e divididos em dois grupos: grupo Experimental, 23 indivíduos que foram tratados com Herbst splint metálico e grupo Controle, 23 indivíduos que foram acompanhados sem tratamento. Os grupos experimental e Controle foram pareados por gênero e idade cronológica. Foram usadas telerradiografias cefalométrica em 45o dos lados esquerdo e direito da mandíbula antes do tratamento (T1) e após período de 8 meses de tratamento e seguinte (T2) para avaliar as mudanças dento esqueléticas. Análise estatística foi realizada com o índice de Correlação Intra Classe e teste t de Student de acordo com a hipótese do estudo. Os resultados mostraram que houve correçãoda relação de Classe II no período de 8 meses por movimento mesial do primeiro molar inferior. O aparelho teve pequena influencia na estrutura mandibular e comprimento mandibular e nenhuma influência na estrutura maxilar e molar superior. Em conclusão,o tratamento tardio da má-oclusão de Classe II com o aparelho MESPHER foi alcançado através de mudanças dento alveolares.

Palavras chave: *Má oclusão de Angle Classe II; aparelhos Ativadores; ortodontia.*

INTRODUCTION

The concept of "jumping the bite" introduced by Kingsley in 1880 has been widely used by clinicians in the treatment of Angle Class II malocclusion associated with mandibular retrusion[1,2].Orthopedic treatment has improved over time, leading to better removable orthopedic appliances[3]. In 1979 a fixed version was reinstated by Pancherz with the name of its creator, Emil Herbst[2,4].

Orthopedic appliances are usually used for correcting mandibular retrusion when the patient is still growing. It was formerly believed that it was not possible to achieve orthopedic correction Class II malocclusion with mandibular retrusion after

growth had ceased[5]. A review of the literature shows consensus that the best time for treatment would be immediately after the pubertal growth spurt because of the short growth period remaining. This would mean shorter retention time and immediate permanent intercuspation, which would prevent relapse[5-11].

There has been increasing attention to use of the Herbst appliance not only in children and adolescents, but also for late treatment, i.e. in subjects who are at the end of their growth period or with no growth remaining[5,10,12-15].

Most studies analyzing treatment with Herbst appliance use lateral radiographs. However,lateral to oblique radiographs offer the benefit of observing the mandibular structure on each side separately with no superimpositions of bone and tooth structures[16,17].

The aim of this study was to evaluate changes induced by late orthopedic treatment with Herbst appliance for Class II division 1 malocclusion with mandibular retrusion in subjects with permanent dentition who were at the end of their growth period, through the use of lateral oblique cephalometric radiography.

MATERIAL AND METHODS

This retrospective study was reviewed and approved by the Ethics Committee under number 39799514.3.0000.5416. The sample consisted of 46 patients who had Class II division 1 malocclusion with mandibular retrusion. Twenty-three consecutive patients (13 male and 10 female, mean age 15.6 years) were treated with a Metallic Splinted Herbst (MESPHER) appliance and assigned to the Experimental group.Another twenty-three patients without treatment were selected from *Burlington Growth Centre* archives and paired with the treated group by gender, age and malocclusion, and used as the Control group.

Inclusion criteria were bilateral Class II molar relationship; overjet greater than 5 mm and complete permanent dentition, except third molars. Exclusion criteria were patients with syndromes or extreme vertical growth pattern. Facial analysis consisting of convex profile, straight nasolabial angle, short mentocervical line and occlusal characteristics consisting of molar and canines in Class II (more than half cusp) and large overjet were used to determine that the subjects had skeletal Class II division 1 malocclusion.

Subjects in the Experimental group used Metallic Splinted Herbst (MESPHER) appliance (Fig.1)for eight months (mean 8.50 ± 0.70 months) with one-step mandibular advancement to an incisor edge-to-edge relationship. The telescopic mechanism used was the Flip-Lock Herbst® (TP Orthodontics, Inc.) model. The upper anchorage was a metallic splint structure in which upper bicuspids and molars were held together and united by a transpalatal welded bar (Fig. 1A). The lower anchorage was a metallic splint structure in which lower bicuspids and molars were held together and united by a lingual welded bar (Fig. 1B).

Lateraloblique cephalometric radiographs of both sides of the mandible before treatment (T1) and after

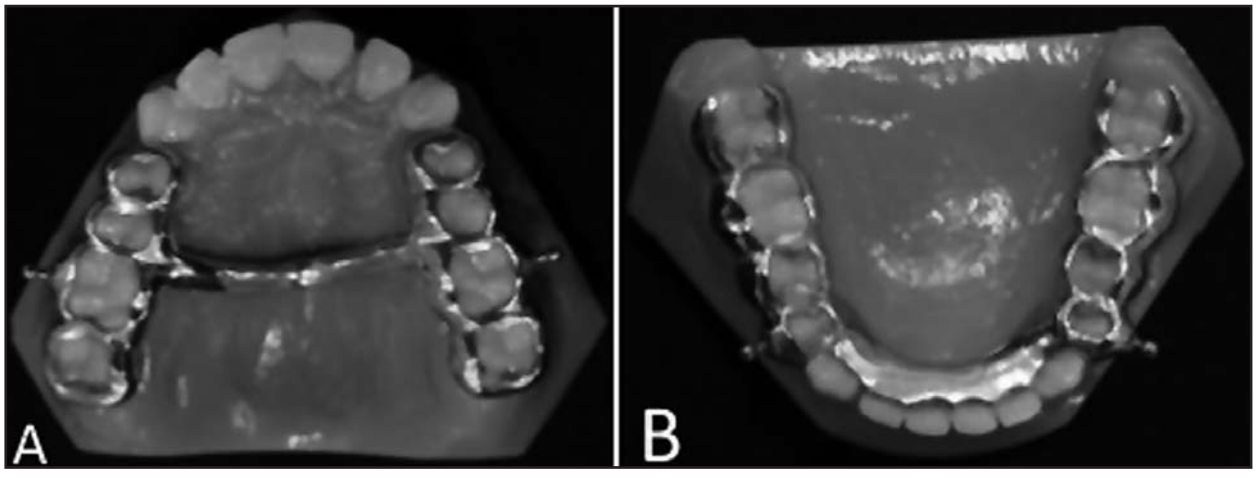

Fig. 1: Upper (1A) and lower (1B) metallic splint built as part of the anchorage system of the metallic splinted Herbst appliance (MESPHER).

treatment (T2) were used to evaluate dental skeletal changes induced by MESPHER. Radiographs were taken with a *Rotograph Plus MR05* device with 10% magnification. In the Control group, the same radiographs of both sides of the mandible of untreated patients were used to evaluate dental skeletal changes due to natural growth development at the same mean ages as subjects in the Experimental group. The radiographs were taken using a *Kelet* radiographic device with 9.84% magnification.Data from the Control and Experimental groups were adjusted to match the mean treatment time.

Skeletal age was verified in carpal radiographs by one investigator (T.B.R.), following Greulich and Pyle[18], and indicated that patients were in the final pubertal growth phase.

Radiographs were digitized with *Numonics Accu Grid* table and the data were obtained using the software *Dentofacial Planner Plus* 2.01. Measurements were randomly reevaluated after two weeks by the same examiner and the error of the method was evaluated using Interclass Correlation Coefficient (ICC).Cephalometric analysis consisted of 16 points marked on right and left lateral oblique radiographs of the mandible. A Cartesian coordinate system was used where theX-axis was defined as the horizontal line represented by the orbital plane determined in the initial radiograph (T1) and transferred to the subsequent radiograph through superimposition of the cranial stable structures[19]. The Y-axis was defined as the vertical line perpendicular to the orbital plane registered in a posterior fiducial point.

The distance of a perpendicular projection of selected dental and skeletal points in the T1 and T2 superimposed radiographs to the X-Axis and Y-Axis was measured to obtain horizontal and vertical dental and skeletal changes, respectively (Fig. 2), in both groups.

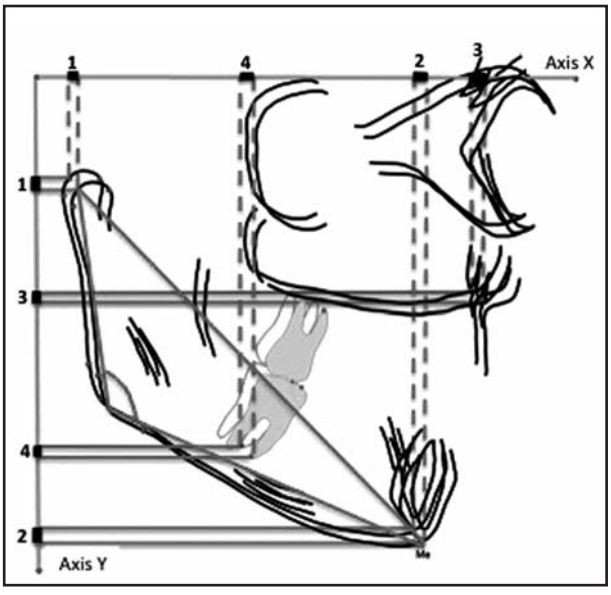

Fig. 2: Points projected on the X-axis (for horizontal changes) and Y-axis (for vertical changes). The displacement between projected points was measured. Examples for mandibular changes (1 and 2), maxillary changes (3), dental changes (4). Md length (linear distance between Condilium and Mentonium), Mdheight (linear distance between Condilium and Gonium), Md horizontal length (linear distance between Gonium e Mentonium), Md Angle (angle formed by intersection of the lines Co-Go and Go-Me).

Statistical Analysis

The following analyses were used to assess the study hypothesis: 1. *Interclass Correlation Coefficient* evaluate measuring method reproducibility; 2. *Student t-test* test mean equality between two independent populations, to test the hypothesis that a population's mean is equal to zero for each group separately and to test mean equality of two populations with independent samples; 3. *Student t-test* for mean equality of two populations with independent sample preceded by Levene test for variance equality. When Levene test showed different variances, Student t-test was corrected accordingly.

RESULTS

The effects of treatment (Experimental group) compared to natural growth (Control group) showed skeletal and dental changes. Analysis of the horizontal and vertical mandibular changes on each side (Tables 1 and 2) showed that variables related to gonium (Go), mentonium (Me), mandibular length (Md length), horizontal length (Mdhor length), mandibular height (Md height) and mandibular angle (Md angle) underwent some small changes. Changes in the same variable differed on the right and left side of the mandible. Only the condyle (Co) presented no significant change. Maxilla showed no significant horizontal or vertical change regarding the points PNS and ANS (Table 1).

Regarding dental movements (Table 1), there were no significant horizontal and vertical changes for Upper First Permanent Molar, either for crown (*UMC*) or apex (*UMA*). However, Lower First Permanent Molar

Table 1: Measurement changes over 8 months in treated and control groups. Mean difference and standard error (SE) .

		Horizontal				Vertical			
Variable	**side**	**Control**	**Experimental**	**difference**		**Control**	**Experimental**	**difference**	
Co	R	1.70(1.4)	0.79(1.7)	0.91(0.5)	ns	0.33(1.8)	0.54(1.3)	0.21(0.5)	ns
	L	1.39(1.1)	2.15(1.9)	0.76(0.5)	ns	0.35(1.3)	1.43(2.7)	1.09(0.6)	ns
Go	R	1.35(1.8)	0.73(1.7)	0.62(0.5)	ns	1.32(1.7)	0.13(1.5)	1.45(0.5)	**
	L	1.61(1.4)	0.53(1.5)	1.08(0.4)	*	0.07(1.3)	0.45(1.5)	0.38(0.4)	ns
Me	R	0.24(0.7)	0.20(0.8)	0.04(0.2)	ns	0.14(0.8)	0.38(0.8)	0.53(0.2)	*
	L	0.05(0.6)	0.09(0.6)	0.14(0.2)	ns	0.34(0.6)	0.09(0.8)	0.25(0.2)	ns
ANS	R	0.15(2.6)	0.43(2.7)	0.57(0.8)	ns	0.67(2.2)	0.24(3.3)	0.43(0.8)	ns
	L	0.36(2.2)	1.05(2.5)	0.69(0.7)	ns	0.74(1.7)	0.63(3.5)	1.37(0.8)	ns
PNS	R	0.58(3.2)	1.29(4.3)	1.87(1.1)	ns	0.15(2.6)	0.43(2.7)	0.57(0.8)	ns
	L	0.66(3.6)	0.98(4.9)	0.33(0.3)	ns	0.36(2.2)	1.05(2.5)	0.69(0.7)	ns
UMC	R	0.34(3.7)	0.47(3.8)	0.13(1.1)	ns	1.12(1.8)	0.89(1.6)	0.23(0.5)	ns
	L	0.43(2.3)	1.91(4.2)	1.48(1.0)	ns	0.87(1.0)	0.04(1.9)	0.91(0.4)	ns
UMA	R	0.30(2.7)	0.97(2.6)	1.27(0.8)	ns	1.07(1.7)	0.98(1.5)	0.09(0.5)	ns
	L	0.62(2.0)	0.85(3.7)	0.23(0.9)	ns	0.89(1.0)	0.10(1.8)	0.79(0.4)	ns
LMC	R	0.32(0.9)	1.61(2.3)	1.93(0.5)	***	0.08(1.5)	0.20(1.8)	0.27(0.5)	ns
	L	0.28(1.0)	1.35(0.8)	1.63(0.3)	***	0.29(1.4)	0.00(1.6)	0.29(0.4)	ns
LMA	R	0.24(1.1)	0.57(0.2)	0.33(0.5)	ns	0.12(2.6)	0.13(4.3)	0.02(1.0)	***
	L	0.10(1.0)	0.19(1.3)	0.29(0.3)	ns	0.66(1.7)	0.12(4.6)	0.78(1.0)	ns

Student T Test:*** significant p< 0.001 ; ** significant p< 0.01 ; * significant p< 0.05 ; ns = not significant
Co (Condilium); Go (Gonium); Me (Mentoniano); ANS (anterior nasal spine); PNS (posterior nasal spine); UMC (upper molar cuspid)
UMA (upper molar appex); LMC (lower molar cuspid); LMA (lower molar appex)

Table 2: Mean and standard deviation of measurement changes over 8 months in treated and control groups. Mean difference and standard error (SE).

Variable	side	Control	Experimental	difference	
Md length	R	1.75(1.8)	0.78(2.2)	0.97(0.6)	ns
	L	1.08(1.7)	2.32(2.4)	1.23(0.6)	*
Md height	R	1.69(2.0)	0.41(2.0)	1.27(0.6)	*
	L	0.47(1.7)	2.15(3.0)	1.68(0.7)	*
Md hor length	R	1.14(2.0)	0.77(1.5)	0.38(0.5)	ns
	L	1.47(1.8)	0.23(1.5)	1.23(0.5)	*
Md angle	R	0.96(2.2)	0.39(2.4)	0.57(0.7)	ns
	L	0.95(1.4)	0.69(1.9)	1.64(0.5)	**
Incl molar inf	R	0.95(6.3)	3.494.6)	4.44(1.6)	**
	L	0.63(3.4)	4.81(3.5)	5.44(1.0)	***

Student T test: *** significant p <0.001 ; ** significant p< 0.01 ;
* significant p< 0.05 ; ns = not significant
Md Length (mandibular length); Md height (mandibular heigth); md hor length (mandibular horizontal length)
md angle (mandibular angle); incl molar inf (inclination of lower permanent molar)

had a very significant horizontal change in crown (*LMC*) in mesial direction and showed no apex changes (*LMA*), leading to a significant increase in its inclination (*Incl Molar Inf)*as a result of the treatment (Tables 1 and 2). Additionally, there is statistical evidence that a vertical change occurred on the right side for Lower First Permanent Molar apex (*LMA*) but not on the left side.

DISCUSSION

This lateral oblique cephalometric study evaluated dental skeletal alterationsin subjects withClass II division 1 with mandibular retrusion who were treated with a metallic splinted Herbst appliance. Forty-six patients with mean age 15.6 years were analyzed and divided into treatment and control groups. Although there is an understanding that this kind of treatment would be more appropriate during the pubertal growth peak[7,8,20-24], some studies have shown that treatment through mandibular advancement can be accomplished after this phase[5,6,9,11-15,25].

The condyle region presented no significant vertical and horizontal changes after treatment on either side (right or left) in this sample of young adult patients. In contrast, most studies with Herbst appliance using lateral cephalometric radiographs report different results. In a systematic review, Cozzaet al.[8] showed that supplementary condylar growth is considerably higher when orthopedic treatment is performed during adolescence. Pancherz[3]observed horizontal condylar growth but no vertical change in the treatment group. Ruf and Pancherz[5]examined two treatment groups with ages 12 and 16 years, and observed condylar changes in both groups; however, this change remained only in the 16-year-old group after appliance removal. Subsequently, the same authors[10]reported that patients treated 1 or 2 years after pubertal growth peak showed more horizontal condylar growth. Lateral oblique cephalometry allowsmore precise analysis of each side of the maxilla-mandibular structures and dental components without the disadvantage of superimposition.

Mandible remodeling could be expected as an effect of the treatment. The gonium region showed some horizontal (left side) and vertical (right side) changes.In contrast, Hägglund, Segerdal and Forsberg[21] (2008) observed in 14-year-old boys no difference in mandibular angle after treatment.In agreement withour results, Pancherz[3] reported some resorption of the posterior part of the mandibular body that coincides with the gonial region and also observed that the gonial angle opened in patients submitted to Herbst treatment and closed in the control group. The symphysis region showed a slight vertical change on the right side. This region was used as a superimposition structure in this study because it was considered to be a stableregion[3,15], and was not expected to change over the 8-month period of observation. As result of this remodeling, the mandibular angle increased on the left side.Ruf and Pancherz[11] reported similar results, observing an increase in mandibular angle during treatment in individuals with ages raging from 15 to 44 years, although tit subsequently decreased slightly after appliance removal. Nevertheless different responses in mandibular structure were not enough to produce asymmetry in the final outcome.

Considering effective mandibular length (*Md length*), a slight difference occurred on the left side. In a systematic review[22], it was reported that some studies foundan increase in mandibular length whereas others reported no change. Similarly, Flores-Mir et al.[23], concluded that mandibular length increased in the studies analyzed. Hägglund, Segerdal and Forsberg[21]found no skeletal change between treatment and control groups in a study on 14-year-old boys. Likewise, Konik, Pancherz and Hansen[9] reported no mandibular increase in a treatment group after pubertal growth peak. However, Pancherz[3]found an increase in mandibular length three times higher in the treatment group than in the control group. Subsequently, Ruf and Pancherz[5] reported less mandibular increase and more dental movement in 16-year-old subjects. In 2003, the same authors[10] reported an increase in mandibular length in patients treated 1 or 2 years after the pubertal growth peak. This inconsistency was explained by the fact that different measurements were used in each study.

Mandibular horizontal length has not been widely discussed and has only been evaluated by Pancherz[3], who observed a decreasein the length of mandibular corpus after treatment. This is in agreement with our results, which showed asmall change in the gonium on the left side as part of the mandible remodeling process.

Mandibular height changed significantly in the vertical direction on both sides of the mandible. In agreement with this result, the systematic review by Flores-Mir et al.[23]found an increase in

mandibular height in the studies analyzed. Pancherz[3] also reported that in a retention period after 7 years of appliance removal, treated patients presented increased mandibular height while the control group did not.Horizontal and vertical gonium remodeling must have contributed to this height change, considering that the condyle did not undergo any modification.

Information in the literature on maxillary bone only reports that there was restriction of its displacement as the effect of treatment. Only Pancherz[3]reported maxillary restriction during treatment. Our results show that the anterior and posterior nasal spine had the same pattern of horizontal and vertical movements as in the control group, indicating that the treatment did not change the natural displacement of the maxilla, in agreement with other studies[9,11,21,22]. The stability of the maxillary position may be attributed to the metallic splint utilized as anchorage.

Dental movement appeared to be more marked. High significance was observed on both sides on lower permanent first molar for crown and no significance whatsoever for apex in horizontal assessment. It is understood that mesial inclination occurred, also confirmed by a measurement that showed great significance for axial movement. Barnett et al.[22] also observed extrusion and mesial movement of lower first permanent molars. Most studies with Herbst appliance on subjects of the same age agree with these results[3,5,22,23], confirming that Class II is corrected mostly by dental movement. With regard to vertical assessment, significance was low for the apex region on the right side. It is understood that extrusion might have occurred. This difference between sides in our study is less than 1mm, being slightly greater on right side than on the left side in absolute values.This small sample difference between sides is what causes this apparent contradiction in the results.

Upper first permanent molars, on the other hand, showed no change, indicating positional stability which could be attributed to the metallic splint used as anchorage. This result contrasts with the literature, which reports intrusion[22] and distal movement[3,23]of the upper molar in conventional Herbst anchorage.

Overall, studies seem to be positive in relation to late treatment for Class II with mandibular retrusion. A recent study[7] concluded that treatment of this kind of malocclusion with the Herbst appliance is equally efficient in adolescents and adults, opening a new option even for borderline patients, because most results for late treatment are more dental than skeletal[3,24]. To paraphrase Pancherz[3], the Herbst appliance improves mandibular positioning in the long term, but does not normalize it. Dental sagittal relation, on the other hand, is practically normalized. Therefore, in the long term, dental effects compensate an unfavorable mandibular relation.

It can be concluded from this study that the treatment of Class II with mandibular advancement using metallic splinted Herbst showed small skeletal influence on the mandible in 14- to 18-year-olds. Dental effects where more significant for the correction of Class II, emphasizing the correction by lower first molar tipping to mesial direction. There is evidence that the mandible responds differently on each side when undergoing an 8-month mandibular advancement treatment. Nevertheless, this differential response is not marked enough to produce an asymmetric final outcome or compensate some small differences between sides due to asymmetric functional masticatory balance.

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Edentulism and its relationship with self-rated health: secondary analysis of the SABE Ecuador 2009 Study

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ABSTRACT

Edentulism is related to a number of conditions in older adults, impacting their overall health status and thus their quality of life and relationship with the environment. At the same time, self-rated health has been shown to be an accurate marker of overall health status. However there is little information on how edentulism relates to self-rated health in older adults of Hispanic origin.

The aim of this study was to evaluate the impact of edentulism on self-rated health in older adults.

We analyzed data from SABE Ecuador 2009, a cross-sectional study that included a probabilistic representative sample of 5,235 community-dwelling older adults aged 60 years or older. The dependent variable was self-rated health and the independent variable was edentulism, with age, sex and comorbidities as confounding variables.In order to test the independent association of edentulism with self-rated health, a logistic regression model was fitted.

Out of the whole sample,77.13% of older adults reported having fair/poor self-rated health. We found an independent association between edentulism and self-rated health with incremental risk according to number of missingteeth,ranging from OR 1.35 (CI 95% 0.75 - 2.43) p 0.32 for less than 4 missing teeth to OR 1.88(1.06 - 3.32) p 0.029 for more than half of teeth missing.

Even though oral health has long been considered separately from the rest of the body and mind, it is clear from our results that oral health is a very important component of global health status in the elderly.

Keywords: *Oral health, edentulous, health status, dental care, aging.*

Relación del edentulismo con la autoevaluación del estado de la salud: un análisis secundario del estudio SABE Ecuador 2009

RESUMEN

El edentulismo se ha asociado con una gran variedad de condiciones en los adultos mayores afectando el estado general de su salud. Por lo tanto, afecta la calidad de vida de la persona y su relación con el medio ambiente. Por otro lado, la autoevaluación de la salud ha demostrado ser un marcador preciso del estado general de la salud. Sin embargo, hay escasa información sobre cómo estas dos condiciones se relacionan entre sí en adultos mayores de origen hispano.

El objetivo de este estudio fue evaluar el impacto del edentulismo en la autoevaluación de la salud en adultos mayores.

Se analizaron los datos de SABE Ecuador 2009, un estudio transversal que incluyó una muestra probabilística y representativa de 5.235 personas de 60 años de edad o más. La variable dependiente fue la salud autoevaluada y edentulismo fue la variable independiente, teniendo edad, sexo y comorbilidades como variables de confusión. Con el fin de probar la asociación independiente de edentulismo con la auto-evaluación de la salud un modelo de regresión logística se ajustó.

De la muestra entera, un 77,13% de los adultos mayores reportaron tener salud auto-evaluada regular / pobre. Se encontró una asociación independiente entre edentulismo y salud autoevaluada con un riesgo incremental dependiendo del número de dientes ausentes de OR 1,35 (IC 95% 0,75 - 2,43) p 0,32, en adultos mayores con menos de 4 dientes ausentes hasta OR 1,88 (1,06 - 3,32) p 0,029, con más de la mitad de dientes ausentes.

La salud oral se ha considerado de forma independiente del resto del cuerpo y la mente, es claro por nuestros resultados que la salud oral es un componente muy importante del estado de salud global en las personas mayores.

Palabras clave: *Salud oral, edentulismo, estado de salud, cuidado dental , envejecimiento.*

INTRODUCTION

Oral health is an indicator of general health condition in older adults[1]. It is estimated that older age brings a higher risk of losing teeth[2], which leads to nutritional alterations, swallowing disorders, variations in language modulation, low self-esteem, poor performance of the individual in society, infections,and changes in physical and mental state. In short, it affects theperson's quality of life (QOL) and relationship with the environment[2-5].

Edentulism is defined as partial or total non-traumatic loss of teeth[6], usually due to infectious pathologies (e.g.dental caries, parotitis and periodontal disease) chronic exposure to toxic substances, smoking, medications (e.g. antihistamines, diuretics, antipsychotics and antidepressants), metabolic factors (e.g. malnutrition, Paget's bone disease or osteoporosis with maxillary involvement) and anatomical/functional alterations such as bruxism[7]. However, asedentulism commonly occurs in older adults, it has multifactorial etiology.

Progressive loss of teeth has been considered part of normal aging because of the high prevalence of tooth loss in older adults[3,8]. However, this idea is inaccurate and several studies have related tooth loss to etiological factors such as chronic disease, rural residence, functional dependence, neurocognitive disorder, low educational level, poverty, poor access to health services, limited access to cultural property and inadequate hygiene habits. In other words, losing teeth is not a part of aging but a consequence of negative conditions existing since childhood, a time when it is important to establish oral health strategies that should continue throughout life[9-11].Edentulism has been documented and found to exert significant effect on individual performance, functionality and well-being[4,12,13].

Self-rated health (SRH) is the summary of all available information oncurrent health status including clinical, mental and social characteristics, according to the patient's circumstances. In recent years, SRH has become an important research target as it is a useful marker for a comprehensive approach to the geriatric patient[14,15].

Positive correlations have been found between objective and subjective health assessments among older adults, mostly in those with disability,[16] chronic diseases[17] or depression[18,19].

Although there are studies on the impact of oral health on SRH in the elderly, the current study goes further and looks at the impact of edentulism on their subjective assessment of their health. The aim of this study was to evaluate the impact of edentulism on SRH in the elderly, in a secondary analysis of the SABE Ecuador study.

MATERIALS AND METHODS

We analyzed data from the SABE (*Salud, Bienestar y Envejecimiento*) Study conducted between June and August 2009in Ecuador. SABE was a cross-sectional study that included 5,235 subjects aged 60 years or more living in rural and urban areas of Ecuador (except Amazon and Galápagos). It was conducted by the*Instituto Nacional de Estadistica y Censos (INEC)*, Department of Socio-demographic Statistics. Funding was provided by the Ministry of Social and Economic Inclusion of Ecuador. The University of San Francisco de Quito, the National Institute of Statistics and Census, the Ministry of Public Health, and the Society of Geriatrics implemented and supported the study.

The instrument used in the SABE Ecuador study was derived from the international instrument designed for the original SABE study conducted in 5 Latin American capital cities[20]. Probabilistic sampling by clusters (housing segments) and block stratification represented 15 continental provinces, according to the Costa and Sierra Regions, urban and rural areas, Quito and Guayaquil. The sample included 10,368 households: 5,100 in the Sierra Region and 5,268 in the Costa Region, including 864 sectors altogether. Of the sample, 85.8% corresponded to subjects with complete data, who were included for analysis[21,22].

Field staff was carefully selected and trained to gather high-quality data.The instruments (handbook and form) and the cartography used were managed efficiently.Inter and intra-observer reliability tests were performed, as well as test-retest using simple correlations.The survey included questions on socio-demographic characteristics (age, sex, education, social support, work/income history), cognitive status, health(cognitive and physical function status, number of medications, services), social networkand family support, work and income history, housing conditions, physical performance and exposure to violence and abuse.

SRHwas evaluated by the question "Do you consider your health status to be excellent, very good, good, fair and poor?" Answers were subsequently dichotomized into good (very good & good) and bad (fair & poor).

Edentulism was used as the independent variable. It was defined as absence of teeth (total or one tooth) and evaluated by the question: "Now, I would like to ask some questions about your mouth and your teeth. Please tell me whether any of your teeth are missing using the following response options: No- I have all my teeth; Yes- a few (up to four); Yes- quite a few (more than four but less than half); Yes- most of them (more than half) or Yes- all missing.

Age was classified as 60-69, 70-79 and ≥80.

Depression was evaluated on the Yesavage Scale for screening depression in older adults, where scores 0-5 indicate normal and 6-15 indicate depression[23,24].

Medical conditions were assessed by asking participants whether they had been diagnosed by a physician with diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD) or arthritis. Pain was evaluated with the question: "Do you have any pain in your back?", "Do you ever have headache?", "Do you feel any pain in your joints?"[25]. For the analysis, answers were dichotomized (Yes/No).

Initially, we used univariate analyses to explore extreme values and a normal distribution to adjust and categorize variables. For descriptive statistics, categorical variables are presented using frequencies (absolute and relative), while means and standard deviations (SD) are used for continuous variables. Bivariate analysis was applied subsequently to contrast SRH differences between groups. Chi-square tests were used for categorical variables and t-tests for continuous variables. Finally, multivariate analysis logistic regression models were fitted in order to obtain the odds ratio (OR) with 95% confidence intervals(95% CI). Estimates are presented before and after adjustment by sex, age and depression. Statistical level of significance was set at $p < 0.05$. Data were analyzed employing STATA 12®.

This study was approved by the Ethics and Scientific Committee of the Ageing Institute at Hospital Universitario San Ignacio and by the Ethics Committee of the Pontificia Universidad Xaveriana. It was conducted in accordance with the ethical standards set forth in the 1964 Declaration of Helsinki and its amendments. Details that might disclose the identity of the subjects under study have been omitted.

RESULTS

Out of the total sample, 77.13% older adults reported having poor/fair SRH (80.59% of women and 73.26% of men). For edentulism, the higher the frequency of poor/fair SRH, the higher the number of missing teeth. Prevalence of poor/fair SRH was 62.30% in persons who had complete dentures,

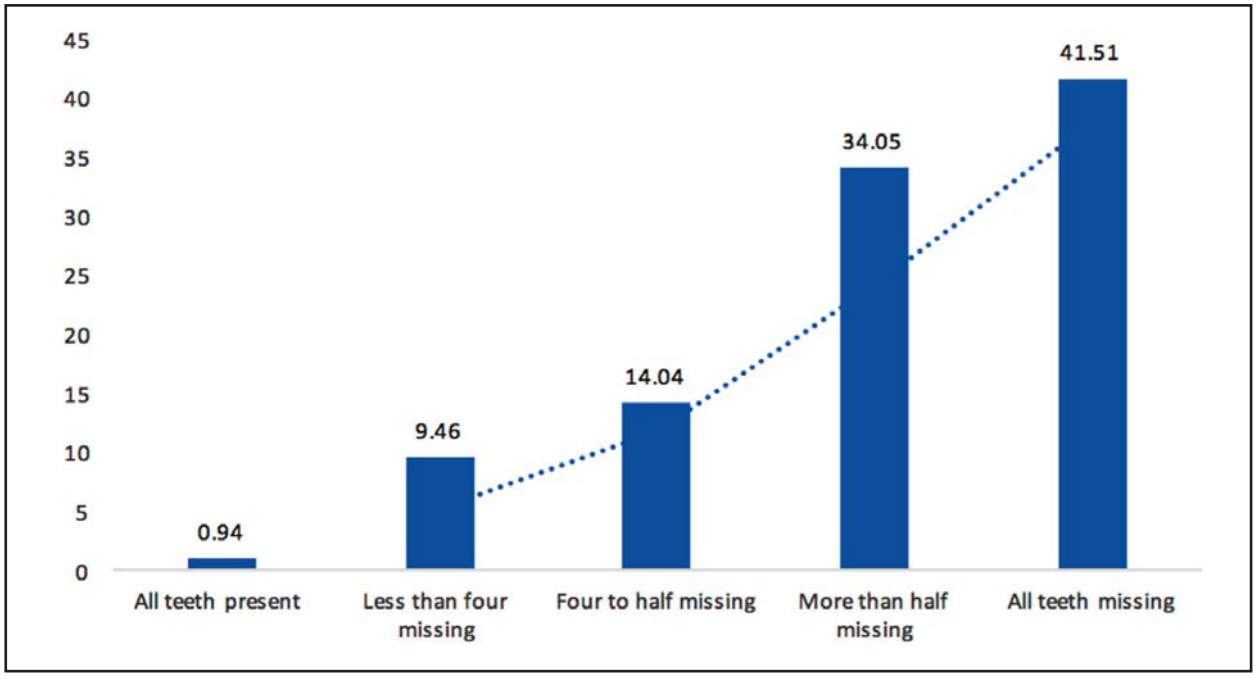

Fig. 1: Percentage of poor self-rated health status according to number of teeth present.

Table 1: Self-Rated Health and Edentulism.

Self-Rated Health	Total 5235 (100)	Poor 4038 (77.13)	Good 1197 (22.87)	P value
	N (%) or mean ± SD	N (%) or mean ± SD	N (%) or mean ± SD	
Edentulism				<0.001
Complete denture	61 (100)	38 (62.30)	23 (37.70)	
Lost up to 4 teeth	553 (100)	382 (69.08)	171 (30.92)	
Lost up to half of teeth	774 (100)	567 (73.26)	207 (26.74)	
Lost more than half of	1752 (100)	1375 (78.48)	377 (21.52)	
teeth				
Complete absence of	2095 (100)	419 (80)	419 (20.00)	
teeth				
Sex				<0.001
Male	2468 (100)	1808 (73.26)	660 (26.74)	
Female	2767 (100)	2230 (80.59)	547 (19.41)	
Age (YO)				0.004
60-69	1094 (100)	803 (73.40)	291 (26.60)	
70-79	780 (100)	612 (78.04)	168 (21.54)	
>80	3361 (100)	2623 (78.04)	738 (21.96)	
Depression				<0.001
Yes	2080 (100)	1853 (89.09)	227 (10.91)	
DM				<0.001
Yes	662 (100)	556 (83.99)	106 (16.01)	
No	4573 (100)	3482 (76.14)	1091 (23.86)	
COPD				<0.001
Yes	413 (100)	364 (88.14)	49 (11.86)	
No	4822 (100)	3674 (76.19)	1148 (23.81)	
Arthropathy				<0.001
Yes	1651 (100)	1421 (86.07)	230 (13.93)	
No	3584 (100)	2617 (73.02)	967 (26.98)	
Head ache				<0.001
Yes	2126 (100)	1885 (88.66)	241 (11.34)	
No	3109 (100)	2153 (69.25)	956 (30.75)	
Back pain				<0.001
Yes	2609 (49.84)	2186 (83.79)	423 (16.21)	
No	2626 (100)	1.852 (70.53)	774 (29.47)	
Joint pain				<0.001
Yes	1449 (27.68)	1265 (87.30)	184 (12.70)	
No	3786 (100)	2773 (73.24)	1013 (26.76)	

78.48% in those with more than half their teeth missing, and highest (80%) in those with total absence of teeth (p <0.001) (Fig. 1).

Other conditions also had high prevalence of poor/fairSRH, such as higher age,depression (89%), diabetes (83.99%), COPD (88.14%), arthropathies (86.07%), headache (88.66%), back pain (83.7%) and joint pain (87%). All of the above were statistically significant with a p value of less than 0.001 (Table1). Multivariate analysis showed that there was independent association between edentulism and SRH, with incremental OR. For <4 teeth, OR was 1.35 (95% CI 0.75-2.43) p 0.32, and for all teeth absent, OR was 1.88 (95% CI 1.06-3.32) p 0.029 (Table 2).

Table 2: Edentulism multivariate regression and SRH unadjusted and adjusted.

	Self-rated health OR (IC95%) P value	
	Unadjusted	Adjusted
Edentulism		
Lost up to 4 teeth	1.35 (0.78-2.33) 0.281	1.35 (0.75 - 2.43) 0.32
Lost up to half of teeth	1.65 (0.96-2.84) 0.067	1.51 (0.84 - 2.70) 0.16
Lost more than half of teeth	2.20 (1.29-3.75) 0.003	1.88 (1.07 - 3.33) 0.03
Complete absence of teeth	2.42 (1.29-4.10) 0.001	1.88(1.06 - 3.32) 0.029
Male sex		0.94 (0.81-1.09) 0.43
Age		
70-89		1.14 (0.91 - 1.45) 0.24
>=80		1.19 (1.00 - 1.41) 0.039
Depression		2.60 (2.20 - 3.06) <0.001
DM		1.49 (1.18 - 1.88) 0.001
COPD		1.70 (1.23 - 2.35) 0.001
Arthropathy		1.26 (0.88 - 1.80) 0.001
Head ache		2.47 (2.10 - 2.91) <0.001
Back		1.45 (0.96 - 2.06) 1.76
Joint pain		1.46 (1.26 - 1.68) 0.079

DISCUSSION

We found an incremental and independent risk association between poor/fair SRH and increasing loss of teeth. Older adults have special needs, particularly in contexts where there is little information on how health variables relate to each other in this particular age group[26]. This is of particular concern in countries where the population is aging rapidly and expected to continue to do so due to demographic transition[13,27]. The frequency of older adults with all teeth present was 1.17%, with the rest of the older adults having at least one missing tooth. Compared to other populations, this number would be considered rather high. Prevalence of edentulismin the general population is 20-65%, depending on geographical location and characteristics of the population evaluated[4,7,10,28]. Few studies in Latin America deal with edentulism in older adults[23,29]. Onesimilar study found a prevalence of 1.7% of non-edentulous older adults and showed linear improvement in SRH using the EQ-VAS as number of teeth increased[4,30]. The incremental association with poor SRH reflects overall poor health; however, the type of study does not enable direct cause-effect to be inferred. Nonetheless, the results do provide an opportunity to determine what complex relations lead to impaired oral health. In addition to the complex interactions of oral health with the rest of the body, specific conditions such as periodontal disease, dental caries and chewing issues increase the risk of losing teeth[13].

This association means that having fewer teeth puts older people at greater risk of having poor SRH, and therefore poor health in general, reflecting the impact of oral health on their health status in general. The fact that the more teeth the older patient has lost, the higher his/her risk of a poor SRH strengthens the association.

Our study has some limitations. First, it is a cross-sectional study and therefore causality cannot be determined. Secondly, self-reported health is used as the outcome variable so recall bias could play an important role in our results. Nevertheless, it reports prevalence rates in a representative sample of older adults in Ecuador, and good agreement between self-reported diseases and clinical diagnoses has been documented.

Oral diseases are some of the most prevalent disorders among the elderly[4,7]. They affect QOL, reduce self-esteem, cause functional impairment and recurrent infections, chewing difficulties, and social and communicational issues. This leads to an increase in the impact of current comorbidities and

new conditions such as malnutrition and frailty[13], which in turn lead topoor oral health in older adults, constituting a public health issue[14,26].

SRH is areflection of objective health status,[17,18] and edentulism is a condition associated with poor SRH. The determinants of poor oral health in the elderly need to be identified in order to reduce its burden and consequences on them[27]. Studies like ours are important to show the relevance of oral health in a population. Further research on oral health is needed, particularly in developing countries, where there are impediments to access to healthcare services, and pain or malaise added to the absence of adequate treatment often lead to tooth extraction. Policy-makers need to address the pubic issue of oral health[26].

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Surface wear of resin composites used for Invisalign® attachments

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ABSTRACT
Orthodontic treatments with Invisalign® require the use of attachments, which are composite resin buttons attached to tooth surfaces. Attachments constitute one of the most powerful tools for improving the efficiency of orthodontic tooth movement. The main purpose of this study was to evaluate surface wear over six months in two resin composites (Filtek Z350 XT, 3M ESPE and Amelogen Plus TW, Ultradent Products Inc.) used for making Invisalign® attachments. These composites were selected for their esthetic and mechanical properties. Forty attachments were bonded to the buccal surface of maxillary teeth. Materials were randomized and assigned in a double blind manner. Impressions were taken of the attachments using a pre-established technique immediately after bonding and following 6 months of clinical use. The impressions were examined by Scanning Electron Microscopy (SEM) at 12-fold magnification to identify changes in surface texture and attachment shape. Data were analyzed using Mann-Whitney's test on the overall ranking of detected changes in those variables.
Statistically significant differences (P<0.001) were found for surface wear, with greater changes in Amelogen Plus. Attachment shape did not change significantly in either material (P>0.05).
According to the results of this study, the alteration of the attachment surface during the first six months of treatment depends on the composite used, while attachment shape does not appear to be affected, so the clinical performance of the materials evaluated could be considered acceptable.

Keywords: *Clear aligner; Orthodontics, attachments; Invisalign; composite, surface wear.*

Desgaste superficial de las resinas compuestas utilizadas en los "attachments" de la técnica Invisalign®

RESUMEN
Los tratamientos ortodóncicos con alineadores Invisalign® utilizan aditamentos construidos en resinas compuestas llamados "attachments" adheridos a la superficie dentaria. El "attachment" es una de las herramientas más potentes para mejorar la eficiencia del movimiento dental.
El propósito de este estudio fue evaluar el desgaste superficial de dos resinas compuestas utilizadas para construir los "attachments" en el tratamiento de ortodoncia con la técnica de alineadores Invisalign®.
Se evaluaron 40 "attachments" adheridos a la superficie vestibular de piezas dentarias del maxilar superior en un período de 6 meses. Los "attachments" fueron construidos en forma aleatoria y a doble ciego con dos resinas compuestas (Filtek Z350 XT de 3M ESPE y Amelogen Plus TW Ultradent Products Inc) elegidas de acuerdo con las propiedades estéticas y mecánicas requeridas. Los "attachments" fueron impresionados con una técnica preestablecida inmediatamente luego de ser adheridos y a los 6 meses. Las muestras fueron preparadas para su observación mediante Microscopía Electrónica de Barrido (MEB) a 12 aumentos. Se observaron los cambios producidos en la textura superficial y la forma entre el inicio y los seis meses de tratamiento. Los datos fueron analizados y comparados utilizando la prueba de Mann-Whitney, realizada en función del ordenamiento global, de menor a mayor según el cambio producido en esas variables.
Los materiales analizados mostraron una diferencia estadísticamente significativa (P<0,001) en el desgaste superficial, siendo el Amelogen Plus el material que evidenció mayor cambio. Las modificaciones en la forma de los "attachments" no fueron estadísticamente significativas en ambos materiales (P>0,05).
Según los resultados obtenidos en este estudio, la modificación de la superficie de los "attachments" durante los primeros seis meses de tratamiento varía en función del composite empleado, en tanto la forma del "attachment" no parece ser afectada de manera similar, por lo que el desempeño clínico podría ser considerado aceptable cuando se emplean los materiales evaluados.

Palabras clave: *Alineadores invisibles; Ortodoncia, attachments; Invisalign; resina compuesta, desgaste superficial.*

INTRODUCTION

In recent decades there has been a remarkable increase in the available range of orthodontic treatments for adult patients who demand esthetics and comfortable alternatives consistent with their modern social and working lifestyles.[1]To satisfy these demands, in 1999 Align Technology (Santa Clara, CA) introduced orthodontic treatments with clear aligners using sequential application of clear alignment devices made from thermoplastic material.

Buttons made of composite resin, known as "attachments", are placed on tooth surfaces as retentive elements and to improve the efficiency of complex tooth movements. Since they are one of the most powerful tools for moving teeth efficiently, it is important that their integrity and shape should remain constant throughout the treatment. [2-5]

An aligner attachment needs esthetic and mechanical properties. In addition to being resistant to stain, it should be the same shade as the tooth or translucent enough to blend with the underlying tooth.[6] It should also be resistant to wear, and it is on this property that the current study focuses.

Composite resin materials are made of an organic phase (matrix) and a ceramic phase (filler) consisting of admixtures of particles of different sizes, which determine the material's properties. According to the clinical requirements, fillers may make up 50% to 70% of the volume, and particle size may range from 20 nanometers to 5 micrometers. [7-9] Higher filler content results in better mechanical properties, while smaller average particle size provides better esthetic properties.[10] Composite resin surface wear has been remarkably reduced through the recent development of nanoparticle resin. [11-14]This study compares two composites of high esthetic and mechanical characteristics with the goal of finding an ideal material for attachments.

The aim of this study was to use Scanning Electron Microscopy (SEM) to determine whether attachment surfaces remain unaltered during the first six months of treatment.

MATERIALS AND METHODS

This study was approved by "Sociedad Argentina de Ortodoncia" Research Ethics Committee resolution number 6-0108/2015.

Ten subjects were selected, male or female, aged 15 to 50 years, who required orthodontic treatment, with full upper dentition and mild or moderate crowding. Patients with mixed dentition, maxillary crown restorations, active periodontal disease and/or edentulous spaces in upper maxillary were excluded. All subjects were treated with Invisalign® aligners. Patients were instructed to brush their teeth with a soft toothbrush (Colgate® Slim Soft) and low abrasive dentifrice (Sensodyne® Pro Enamel).

The attachments were prepared from one of two light-cured resin composite types: Filtek Z350 XT, 3M ESPE orAmelogen Plus TW, Ultradent Products Inc., which have different mechanical and esthetic properties. Materials with high ceramic filler content (72% - 76% by weight) were selected for their translucency and physical properties (Table 1).

Forty (40) attachments were made with Invisalign® Templates on upper maxillary teeth. Materials were randomized for each attachment.

Before attachment preparation, dental enamel was treated following total acid etching protocol with 37% phosphoric acid (Scotchbond™ Etchant, 3M),15-second application. Acid was removed with water spray for 30 seconds and the enamel surface was dried for bonding agent application. A layer of bonding agent (Single Bond 2, 3M ESPE) was applied with a micro-brush and any excess removed by blowing with compressed air. Each attachment was light-cured for 10 seconds (Bluephase G2 Curing Light, Ivoclar Vivadent®) following manufacturer's instructions. The attachment surface was not polished after template removal (Fig 1).

A customized device was designed to use as a tray for attachment impressions. It was prepared from a 6 mm x 6 mm x 6 mm cubic plastic block (Blocky®) customized in an improved stone cast with acrylic (DuraLay, Reliance) for each tooth on which an attachment was placed, in order to provide a consistent insertion pathway for the first and subsequent impressions (Fig. 2 a).

Table 1: Materials tested.

Material	Type	Shade	Filler Content (by weight)	Monomer	Manufacturer	Batch
Filtek Z350 XT	Nanofilled	Amber Translucent	72.5%	Bis-GMA, UDMA, Bis-EMA, TEGDMA	3M ESPE	N593705
Amelogen Plus TW	Micro-hybrid	Translucent White	76%	Bis-GMA	Ultradent products, Inc.	D00B9

Bis-GMA: Bisphenol-A diglycidlethermethacrylate; UDMA: urethane – dimethacrylate; Bis-EMA: Ethoxylatedbisphenol-A dimethacrylate; TEGDMA: triethylene glycol dimethacrylate.

Fig. 1: Attachment preparation. a- Loading the composite into the template. b- Bonding process. c- Attachments on tooth surfaces.

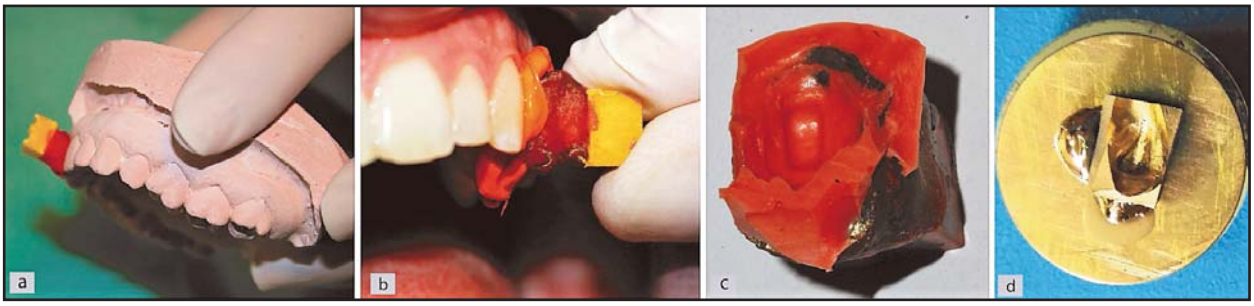

Fig. 2: a- Customized tray for attachment impression. b and c- Impression of an attachment with polyvinylsiloxane. d- Specimen preparation for display in SEM.

Before the attachment impression procedure, an adhesive for silicone impression material was applied over the inner surface of the tray (Universal Tray Adhesive, Zhermack®) and dried with compressed air. Impressions of all attachments were made on the placement day with polyvinylsiloxane (Elite Light Body, Elite P&P Fast Set, Zhermack®, Reorder N.REF C206011) using the manufacturer's syringe and mixing tips (Fig. 2 b,c).

The impressions were inspected under 4.5X magnification to identify any imperfections, cracks in the silicone, pores, etc. Once approved, they were sputter coated (Fig. 2d) and analyzed by SEM (Philips 505). Micrographs were taken at 12- and 100-fold magnifications. The template with which the attachments were prepared was also observed under SEM showing curved lines attributable to the imprint left on the template during the stereolithography manufacturing process (Fig. 3).

The impressions and SEM analyses were repeated at 6 months using the same procedure, for comparative purposes. Images with 12X magnification were the most suitable for evaluating attachment shape and surface texture. They were printed on 13 mm X 18 mm dull photographic paper. Thus, pre- and post-images of each attachment were obtained.

Evaluation

Initial and final photographs for each attachment were numbered on the back. Three observers agreed on a visual order according to changes in surface (texture) and shape. The surface of the attachments showed the stereolithography lines of the template, which were taken as reference for this evaluation. For descriptive purposes, degrees of change were classified according to the following criteria:

Grade 1. Slight or unnoticeable change

Grade 2. Moderate change

Grade 3. Noticeable change (may include cracks or fracture).

Data were analyzed and compared with Mann-Whitney test, performed according to global order from small to large changes in surface and shape (Fig. 4-6).

RESULTS

Comparison of initial and final images showed that all samples underwent some degree of modification of the surface texture, but there was never total destruction of the attachment.

Statistically significant differences ($P<0.001$) were found for surface wear, with greater changes in

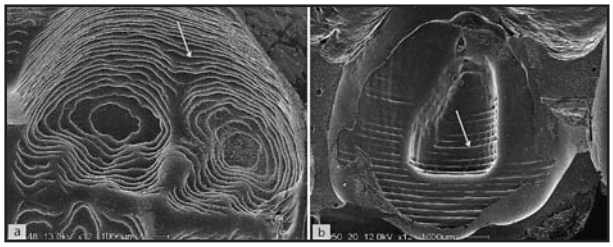

Fig. 3: a- Attachment Template image. 12X magnification. b- Stereolithography lines of the template can be seen on attachment surface.

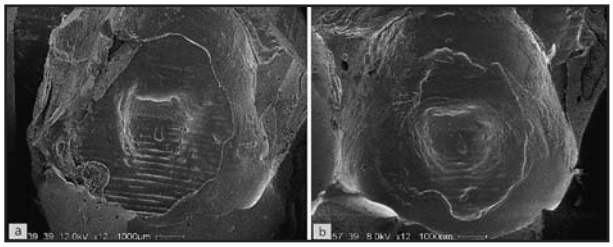

Fig. 4: SEM images (12X) of an attachment showing slight change; baseline (a) and at 6 months (b). Filtek Z350 composite.

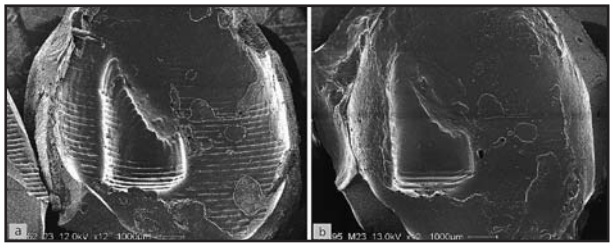

Fig. 5: SEM images (12X) of an attachment showing moderate change; baseline (a) and at 6 months (b). Filtek Z350 composite.

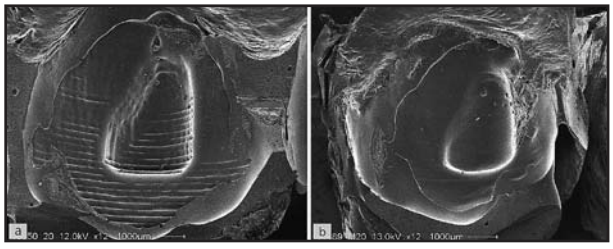

Fig. 6: SEM images (12X) of an attachment showing noticeable change; baseline (a) and at 6 months (b). Amelogen Plus composite.

Table 2: Texture change frequency category according to material.

	Texture			
Material	**Slight change**	**Moderate change**	**Noticeable change**	**Total**
Filtek Z350 XT (3M ESPE)	8	6	4	18
Amelogen Plus TW (Ultradent Products Inc)	1	3	18	22
Total	9	9	22	40

The difference between materials is statistically significant (p<0.001)

Table 3: Shape changes frequency category according to material.

	Shape			
Material	**Slight change**	**Moderate change**	**Noticeable change**	**Total**
Filtek Z350 XT (3M ESPE)	13	5	1	19
Amelogen Plus TW (Ultradent Products Inc)	15	4	2	21
Total	28	9	3	40

The difference between materials is not statistically significant (P>0.05).

Amelogen Plus. Attachment shape showed no significant change (P>0.05). Results for changes in texture and shape are provided in Tables 2 and 3, respectively.

DISCUSSION

In addition to the aligners themselves, treatments using invisible aligners require auxiliary "attachments" to help retain and move teeth.[3,4,15]

In a systematic review, Rossini et al. concluded that transparent aligner treatments require the use of attachments to improve the predictability of orthodontic movement.[2] Another study by the same authors compared complex orthodontic movements with and without attachments, showing the relevance of using attachments to improve the efficiency of the appliance.[16] The composite selected must therefore have adequate mechanical properties. There is currently no published study establishing minimal integrity for proper attachment performance.[6]

Studies *in vitro* and *in vivo* have referred to wear of composite resins in contact with the tooth structure antagonist in occlusal restorations and/or mechanical action of brushing, diet and salivary pH.[17-19]We did not find any analyses of abrasive wear against an antagonist such as the aligner material.

In our study, all final SEM images showed surface differences such as reduction and/or total absence of lines related with the template stereo-lithography impression. The observed changes in the surfaces of the attachments may be produced by the friction generated when placing and removing the aligner, among other causes. Filtek Z350 revealed less surface wear than Amelogen Plus TW after the first six months' use, in agreement with Feinberg et al.[6]Attachment shape did not change significantly for either of the study materials, suggesting that tooth movement related to the attachment would still be effective after six months.

Further research using a larger number of resin materials and longer time periods is needed to quantify the observed changes and their relation to the efficiency of orthodontic tooth movement.

We believe that the results of this study provide a useful contribution to be considered when materials are being selected for making attachments.

CONCLUSION

Attachments used in the Invisalign® orthodontic technique contribute to orthodontic tooth movement. According to the results of this study, the alteration of the surface of the attachments during the first six months of treatment varies depending on the composite used, while the shape of the attachment does not appear to be affected, so the clinical performance of the materials evaluated can be considered acceptable.

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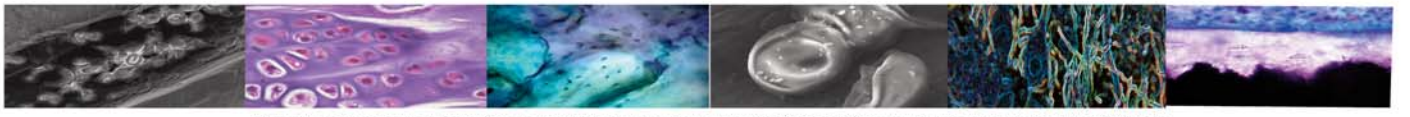

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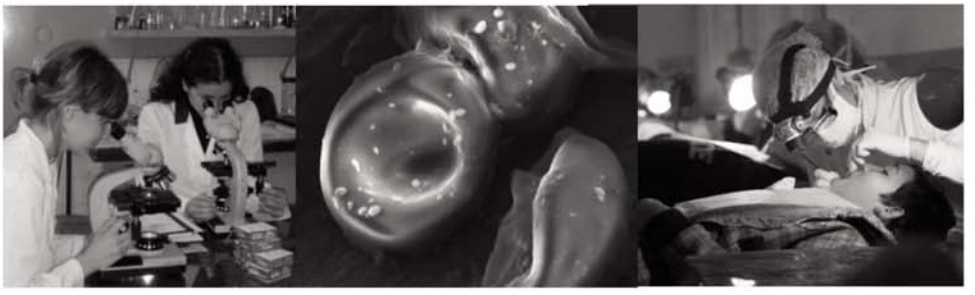

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