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Buccal bone defects and transversal tooth movement of mandibular lateral segments in patients after orthodontic treatment with and without piezocision: A case-control retrospective study

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Introduction: This study aimed to compare the extent of buccal bone defects (dehiscences and fenestrations) and transversal tooth movement of mandibular lateral segments in patients after orthodontic treatment with and without piezocision in cone-beam computed tomography and digital dental models. **Methods:** The study sample of this study consisted of cone-beam computed tomography scans and digital dental models taken before (T0) and after (T1) orthodontic treatment of 36 patients with moderate mandibular anterior crowding. The experimental group consisted of 17 patients that had piezocision performed at the beginning of treatment with the goal of accelerating tooth movement, which was compared with 19 patients who did not receive piezocision. The measurement of bone defects, buccolingual inclination, and transversal distances of the tooth in the mandibular lateral segments (mandibular canines, premolars, and first molars) were evaluated at baseline and at the end of the orthodontic treatment. **Results:** Overall, an increase in dehiscences, buccal inclination, and arch width from T0 to T1 was observed in both groups, but no statistically significant difference was found between groups. A significant increase in fenestrations from T0 to T1 was observed only for the canines in the experimental group. No statistically significant association was found between the increase of dehiscences and the amount of buccolingual inclination or transversal width changes. However, the changes in transversal width were statistically significantly associated with the increase in buccal inclination at the canines, first and second premolars. **Conclusions:** No significant differences were found in buccal dehiscences and transversal tooth movement (buccolingual inclination and arch width) of mandibular lateral segments between patients after orthodontic treatment with and without piezocision. Dehiscences, buccal inclination, and arch width significantly increased from T0 to T1 in both groups. (Am J Orthod Dentofacial Orthop 2021;159:e233-e243)

The duration of orthodontic treatment has become one of the most frequent concerns in patients because of the esthetic demands of society, which makes them request a shorter duration of orthodontic treatment.[1] Thus, accelerating orthodontic tooth movement and reducing treatment time has become one of the main research areas in orthodontics. Surgical interventions to accelerate the rate of tooth movement aim to accelerate bone remodeling by cutting the cortical layer of alveolar bone to induce

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the regional acceleratory phenomenon.[2] The regional acceleratory phenomenon is a localized reaction of soft and hard tissues adjacent to the corticotomy, resulting in increased bone remodeling and a temporary decrease in bone density,[3] which along with conventional orthodontic forces allow an increased rate of orthodontic movement.[1]

Piezocision is a minimally invasive procedure combining gingival microincisions followed by minimal piezoelectric osseous cuts to the buccal cortex to accelerate orthodontic tooth movement, and bone or soft-tissue grafting concomitant with a tunnel approach to enhance periodontium if needed.[4] Recently, several articles have evaluated the effectiveness of piezocision in accelerating orthodontic tooth movement with contradictory results.[5] The relationship between piezocision and periodontal health remains unknown. The region where the osteotomy cuts are made with the piezoelectric knife, usually without bone graft, is a susceptible area for bone defects such as dehiscences and fenestrations even before orthodontic treatment[6,7] as well as after conventional orthodontic treatment,[8] owing to the transverse expansive tendency during the alignment of the arches. Charavet et al[9] reported that dehiscences and fenestrations were similar with or without piezocision; however, no standardization of the methods to evaluate dehiscences and fenestrations, nor transverse dimensions or changes in the buccolingual inclination of the mandibular lateral segments were described. Recently, Raj et al,[10] employing cone-beam computed tomography (CBCT) scans in a randomized clinical trial with and without piezocision, evaluated the marginal crestal bone when retracting canines; they demonstrated that with piezocision, there was a statistically significant gain in bone level in buccal and mesial alveolar bone level.

Little is known regarding the use of piezocision to accelerate orthodontic tooth movement and how it influences the risk of alveolar bone defects. Furthermore, the piezocision relationship with the type and amount of transverse tooth movement that occurs during orthodontic alignment is still unknown. Specifically, this study compared the extent of buccal bone defects (dehiscences and fenestrations) and transversal tooth movements of mandibular lateral segments in patients before and after orthodontic treatment with and without piezocision.

MATERIAL AND METHODS

The methodology described for this case-control retrospective study was approved by the University of CES Ethics Committee (Ae-209). The study sample consisted of before treatment (T0) and after treatment (T1) CBCT scans and digital dental models (DDMs) of 36 consecutive patients that were prospectively collected in a previous study. Within that study, the patient allocation to the groups was done by a randomized draw. Based on the mean values and standard deviations of previous reports,[11,12] and the expected difference between the piezocision and control groups, the sample size of the present study allows us to achieve an 80% power with an $\alpha = 0.05$.

The patients were aged between 18-40 years, with Angle's Class I and mild Class II or III malocclusion, with moderate mandibular anterior crowding and healthy periodontium, who underwent orthodontic treatment with passive self-ligating bracket system (Damon SL; Ormco, Orange, Calif) for 13.86 ± 5.46 months (control group, 14.95 ± 6.023; experimental group, 12.65 ± 4.649). The experimental group consisted of 17 patients who received mandibular piezocision at the beginning of treatment with the goal of accelerating tooth movement. The surgical procedure was performed under local anesthesia. Vertical and interradicular gingival incisions were performed on the buccal surface of the mandibular arch from the right to the left first molar. The incisions were started 2-3 mm below the interdental papilla and with sufficient depth to the periosteum to allow the scalpel to reach the alveolar bone. Then, through the incision, using a piezoelectric scalpel (piezotome), several bone cuts were performed. One corticotomy per incision was performed for a total of 11 mandibular corticotomies per patient. The piezo surgical tip only penetrated the buccal cortex thickness (1-2 mm). The control group consisted of 19 patients who did not receive mandibular piezocision. The piezocision group was followed up every 2 weeks, and the control group was followed up every 4 weeks. Mandibular archwire sequence for both groups was as follows: copper-nickel-titanium, 0.014, 0.018, or 0.014 × 0.025-in; copper-nickel-titanium, 0.018 × 0.025-in; TMA, 0.17 × 0.25-in; and stainless steel, 0.017 × 0.025-in and were only changed when they were no longer active.

The mandibular CBCT scans were acquired, using the Veraviewepocs 3D R100 (J Morita Corp, Tokyo, Japan) following the acquisition protocol: 90 kV; 3-5 mA; 0.16-mm^3 voxel size; scan time, 9.3 seconds; and field of view of 100 × 80 mm. The DDMs were acquired with the TRIOS 3D intraoral scanner (version 1.3.4.5; 3Shape, Copenhagen, Denmark) with an accuracy of 6.9 ± 0.9 μm. Dehiscences and fenestrations were quantified in T0 and T1 for each tooth in the mandibular lateral segments (mandibular canines, first and second premolars, and first molars), using 3D Slicer (version 4.10.1; https://www.slicer.org), following the method validated by Sun et al:[13] (1) the digital imaging and communications in medicine files of the CBCT scans were imported into the 3D Slicer software; (2) all measurements were performed in the largest labiolingual section of each tooth (measurement plane), displayed in the sagittal view. The measurement plane of each tooth was located using 3 red, yellow, and green guidelines that were respectively representing the axial, sagittal, and coronal planes. The axial plane was adjusted, bypassing the red guideline through the cement enamel junction of each tooth in the coronal and sagittal views. Then, the yellow guideline was rotated until it passed through the widest part of the root canal in the axial view, and the yellow and green guidelines were rotated until they passed through the midpoint of the cusp and the root apex in the coronal and sagittal views respectively; (3) the buccal bone defects were measured using the ruler tool in the 3D Slicer. The mesial and distal roots of the first mandibular molars were evaluated individually. The variables and landmarks were described according to Sun et al[14]: (1) dehiscence: alveolar bone defect involving an alveolar margin 2 mm or greater and concurrent with a v-shaped bone margin of the alveolar crest; (2) fenestration: a circumscribed defect on the alveolar bone exposing the root, not involving the alveolar crest; (3) Dh: the distance between A (cementoenamel junction at the buccal side) and B (alveolar crest at the buccal side); (4) Fn: the distance between C (coronal border of a fenestration and D (apical border of a fenestration).

We also set the critical point for dehiscence and fenestration according to Sun et al[14]: the critical point for dehiscence on the CBCT was set at 2 mm and for fenestrations at 2.2 mm, meaning that when Dh was greater than 2 mm, it was classified as dehiscence, and when Fn was greater than 2.2 mm it was classified as fenestration. The flow chart of this image analysis procedure is shown in Figure 1.

Two open-source software, ITK-SNAP (version 2.4.0; Cognitica, Philadelphia, Pa) and 3D Slicer, were used to measure the changes in the buccolingual inclination of each tooth in the mandibular lateral segments, based on the following procedures: (1) Construction of 3-dimensional (3D) volumetric label maps

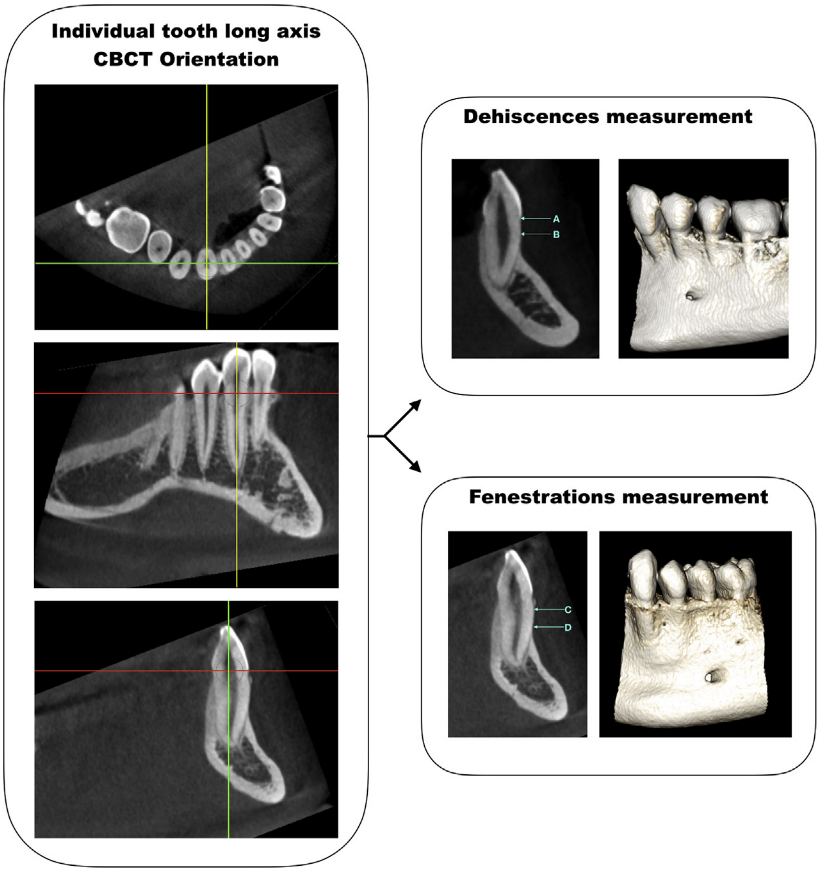

Fig 1. Flow chart: Assessment of buccal bone defects.

(segmentation) of the T0 mandibles from de-identified "gipl.gz" files. (2) From the T0 3D volumetric label maps, T0 3D surface models (CBCT models) were generated for a standardized common orientation, using the transforms tool in slicer software (mandible orientation). Model orientation was achieved by (2.1) aligning the lower border of the mandible with the horizontal plane in the sagittal view; (2.2) aligning the mesial surface of mandibular first molars with the coronal axis; (2.3) aligning the midline with the sagittal axis. Steps 2.2 and 2.3 were done in the axial view having as reference a standardized fixed coordinate system. The matrix generated from the orientation was applied to the T0 scan and segmentation. (3) Approximation of T0 and T1 CBCT scans was achieved having as a reference the mesial-buccal cusp of the second molars, the buccal cusp of the second premolars, and the cusp of the canines using the surface registration tool. (4) Voxel-based CBCT registration of T1 CBCT scans in relation to the oriented T0 CBCT file was achieved using a nongrowing registration module.[15] (5) Prelabeling: 16 3D dots were placed on the oriented (T0) and registered (T1) segmentations. The dots were positioned at the mandibular canines (midpoint of the cusp and the root apex), first and second premolars (midpoint of the buccal cusp and the root apex), and first molars (a midpoint of the mesiobuccal cusp and central point at the apex of the mesial root). After prelabeling, the T0 and T1 mandibular 3D surface models were generated (Visualization Toolkit files). (6) Measurements of the buccolingual inclination were made using the Quantification of 3D Components tool in 3D Slicer software. Landmarks were placed following the prelabeled 3D dots made to determine the long axis of each tooth. The flow chart of this image analysis procedure is shown in Figure 2.

The arch width and Little's Irregularity Index (LII) were measured on the DDM using Ortho Insight (version 7.0.7096; Motion View Software, Hixson, Tenn). The arch width was measured between the occlusal cusp of left and right canines, buccal cusps of first and second premolars, and mesiobuccal cusps of first molars. The LII was calculated by measuring the linear displacement of the anatomic contact points of each mandibular incisor from the adjacent tooth anatomic point. The flow chart of this image analysis procedure is shown in Figure 3.

Statistical analysis

Before performing the measurements of bone defects, 2 observers were calibrated by a radiologist, who repeated measurements for 10 randomly selected CBCT scans 3 times with a 1-week interval in between scans. To assess intraobserver repeatability for inclination and transversal width, we made repeated measurements for 10 CBCT scans and 8 DDM with an interval of 1 week. To assess

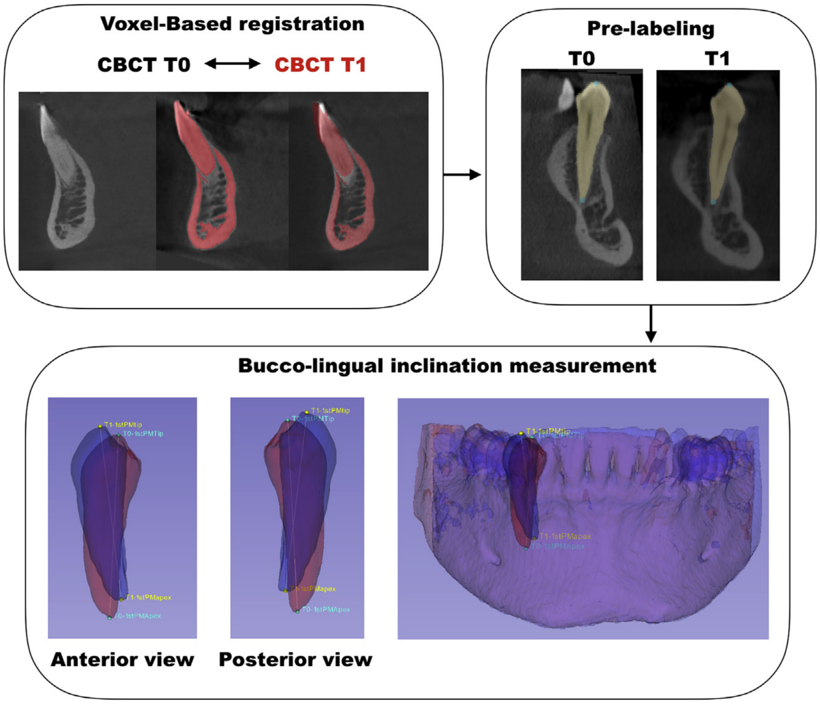

Fig 2. Flow chart: Assessment of buccolingual inclination.

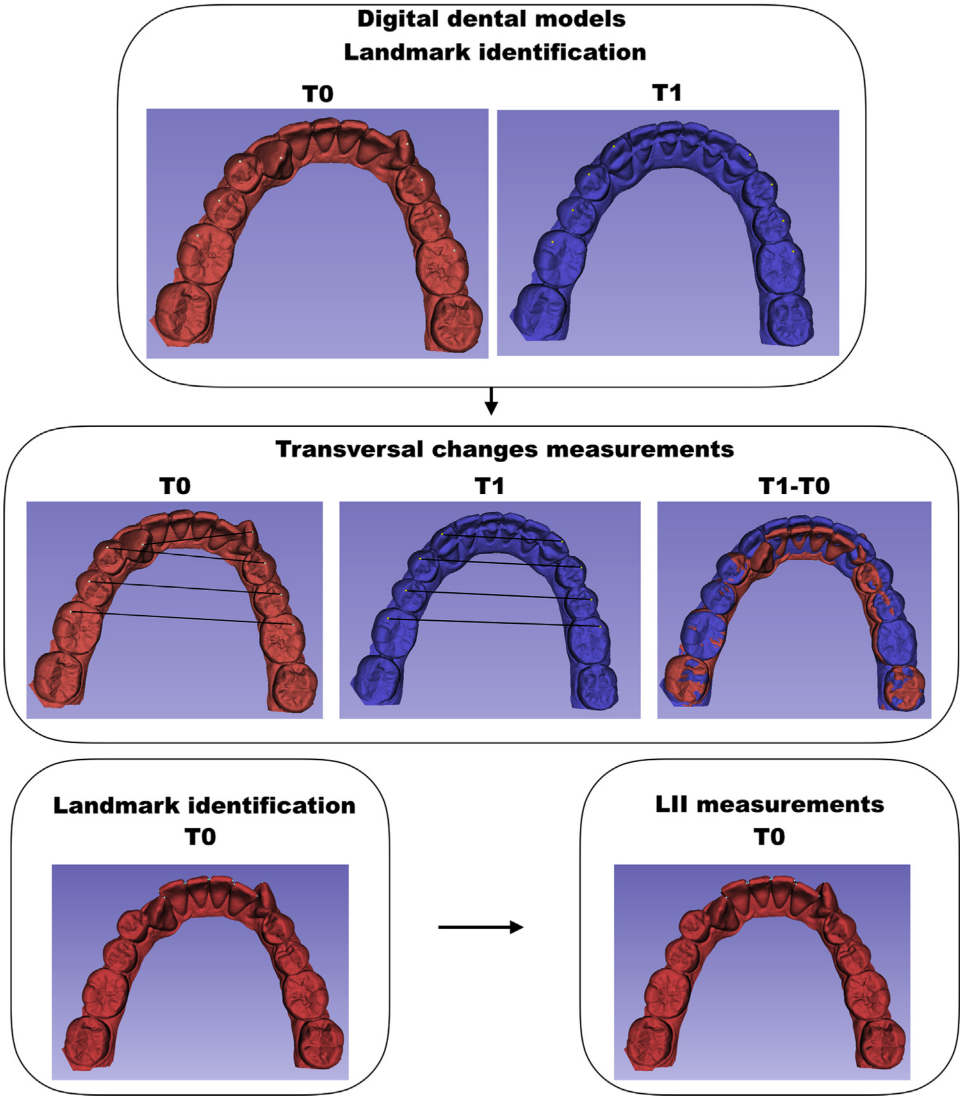

Fig 3. Assessment of arch width and LII.

intraobserver repeatability and interobserver reproducibility, we used the intraclass correlation coefficient (ICC).

Kolmogorov-Smirnov and Shapiro-Wilk tests revealed that the variables of the study did not have a normal distribution. Therefore, nonparametric tests were used. Wilcoxon test was used to compare the right and left teeth measurements, and the intragroup changes from T0 to T1 (T1−T0). Mann-Whitney test was used to compare the differences at T0 between the 2 groups and the T0 to T1 changes between the 2 groups. Pearson correlation coefficient was used to assess the association between buccolingual inclination with dehiscences, transversal width with dehiscences, and buccolingual inclination with transversal width. All statistical analyses were conducted using SPSS Statistics for Mac (version 25.0; SPSS, Chicago, Ill).

RESULTS

All variables had excellent intraobserver repeatability and interobserver reproducibility. The intraobserver and interobserver ICCs for bone defects were respectively 0.98 and 0.97. The intraobserver ICCs for inclination and transversal width measurements were 0.96 and 0.99, respectively. The Wilcoxon test showed no statistically significant difference when comparing the left and right sides in the mandibular lateral segments, so right and left data were pooled together for subsequent analyses.

At T0, no statistically significant differences in age, treatment time, LII, cephalometric variables, bone defects, inclination, and arch width were found between the 2 groups; the study variables at T0 are summarized

Table I. Statistical comparison for age, LII, treatment time, and variables for group 1 (control) and group 2 (piezocision) at T0

	Group 1 (n = 19)		*Group 2 (n = 17)*		*Mann-Whitney test*
Variables	*Mean*	*SD*	*Mean*	*SD*	P *value*
Age (y)	23.84	4.02	25.65	6.93	0.644
LII (mm)	10.68	3.15	9.64	1.51	0.516
Treatment time (mo)	14.95	6.02	12.65	4.65	0.176
ANB (°)	4.09	2.46	3.95	2.49	0.775
Wits appraisal (mm)	1.86	3.14	2.09	2.57	0.634
PM-FH (°)	19.29	5.27	18.71	5.03	>0.999
Gonial angle (°)	115.88	6.45	117.38	7.33	0.274
U1-PP (°)	114.38	7.15	112.40	6.68	0.383
L1-MP (°)	101.33	5.92	99.84	8.01	0.579
Overjet (mm)	3.27	1.23	3.25	1.54	0.937
Overbite (mm)	2.44	1.25	3.11	1.99	0.318
Molar relation (mm)	−0.82	2.18	−0.55	1.55	0.210
Dh canine (mm)	2.20	1.41	1.56	0.83	0.199
Dh first premolar (mm)	2.39	1.03	2.18	0.88	0.623
Dh second premolar (mm)	1.73	0.70	1.43	0.53	0.358
Dh first molar mesial root (mm)	1.39	0.41	1.28	0.59	0.326
Dh first molar distal root (mm)	1.54	0.69	1.41	0.43	0.601
Fn canine (mm)	0.13	0.56	0.22	0.43	0.147
Fn first premolar (mm)	0	0	0.28	0.71	0.060
Fn second premolar (mm)	0	0	0.29	1.01	0.129
Fn first molar mesial root (mm)	0	0	0	0	>0.999
Fn first molar distal root (mm)	0	0	0	0	>0.999
3-3 width (mm)	25.29	2.16	25.88	2.98	0.350
4-4 width (mm)	32.80	2.08	33.40	3.1	0.350
5-5 width (mm)	38.21	2.33	38.44	4.02	0.987
6-6 width (mm)	44.48	2.26	44.93	3.18	0.476

SD, Standard deviation.

in Table I. Means and standard deviations for Dh, Fn, and Arch width at T0, T1, and T1−T0 are summarized in Tables II and III. Means and standard deviations for buccolingual inclination are summarized in Table IV.

Mandibular buccal Dh increased from T0 to T1 for both groups. In the control group, Dh significantly increased for the canines (mean, 1.8 ± 2 mm; $P = 0.001$), first premolars (1.4 ± 1.7 mm; $P = 0.004$), and first molars mesial root (0.79 ± 1.08 mm; $P = 0.001$). In the piezocision group Dh significantly increased for canine (1.84 ±2.39 mm; $P = 0.002$), first premolars (1.14 ± 1.93 mm; $P = 0.039$), first molars distal root (0.96 ± 2.52 mm; $P = 0.006$), second premolars (0.88 ± 1.1 mm; $P = 0.002$), and first molar mesial root (0.53 ± 0.73 mm; $P = 0.003$). When comparing the changes T1−T0 for Dh between both groups, no statistically significant difference was found.

In the control group, mandibular Fn was not significantly increased from T0 to T1 for all teeth. In the piezocision group, mandibular Fn had a statistically significant increase from T0 to T1 in the buccal surface of the canines ($P = 0.012$). When comparing the changes T1−T0 for Fn between both groups, no statistically significant difference was found, except for the canines ($P = 0.006$) (Table II).

Table III shows the absolute frequency and percentage of root surfaces with dehiscences and fenestrations before and after treatment for both groups. In the control group, the dehiscences increased from 13.16% at T0 to 28.42% at T1. The highest increase was found in the buccal surfaces of the mesial root of the first molars (28.95%), canines (15.79%), and first premolars (15.79%). In the piezocision group, the dehiscences increased from 8.82% at T0 to 25.88% at T1. The highest percentage of increase in dehiscences was found in the buccal surfaces of canines (23.53%), second premolars (17.65%), and mesial root of first molars (17.65%). In the control group, the fenestrations at baseline were present only in the buccal surface of canines with 2.63% and did not increase at T1. In the piezocision group, the fenestrations in the buccal surface of premolars decreased from 2.94% at T0 to 0% at T1, and no fenestrations were found in the buccal surface of canines and first molars before and after treatment.

Both control and piezocision group showed small increases in the buccal inclination for canines (2.23 ± 2.5° and 2.28 ± 2.24°, respectively), first premolars (4.9 ± 2.6° and 4.9 ± 2.9°, respectively), second premolars (6.74 ± 2.6° and 6.8 ± 4.2°, respectively), and first molars (1.16 ± 2.15° and 0.66 ± 2.19°, respectively). The buccal inclination was greater for the first and second premolars, followed by the canines. The first molars showed less buccal inclination and more body movement. When comparing the changes for inclination between both groups, no statistically significant difference was found (Table IV).

Arch width increased from T0 to T1 for both groups. In the control group the transversal width significantly increased for canines (2.28 ± 1.74 mm; $P < 0.001$), first premolars (2.53 ± 2.24 mm; $P = 0.002$), second premolars (2.9 ± 2.4 9 mm; $P = 0.002$), and first molars (0.95 ± 2.25 mm; $P = 0.006$). In the piezocision group the transversal width significantly increased for canines (1.36 ± 2.13 mm; $P = 0.019$), first premolars (2.16 ± 1.72 mm; $P = 0.001$), second premolars (3.19 ± 2.18 mm; $P < 0.001$), and first molars (1.27 ± 1.26 mm; $P = 0.002$). When comparing the changes

Table II. Treatment outcome comparison of Dh, Fn, and width in the mandibular lateral segments at T0, T1, T1−T0 for groups 1 (control) and 2 (piezocision)

	Group 1 (n = 19)									*Group 2 (n = 17)*									*T1−T0 (Group 1 vs 2)*
	T0		*T1*		*T1−T0*		*95% CI*		*Wilcoxon test*	*T0*		*T1*		*T1−T0*		*95% CI*		*Wilcoxon test*	*Mann-Whitney test*
Variables (mm)	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Lower*	*Upper*	P *value*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Lower*	*Upper*	P *value*	P *value*
Dh canine	2.20	1.41	4	2.13	1.80	2.00	0.84	2.77	0.001	1.56	0.83	3.41	2.47	1.84	2.39	0.61	3.07	0.002	0.716
Dh first premolar	2.39	1.03	3.79	1.82	1.40	1.70	0.58	2.23	0.004	2.18	0.88	3.32	1.69	1.14	1.93	0.15	2.13	0.039	0.438
Dh second premolar	1.73	0.70	2.39	1.41	0.66	1.39	−0.01	1.33	0.053	1.43	0.53	2.32	1.15	0.88	1.10	0.32	1.46	0.002	0.274
Dh first molar mesial root	1.39	0.41	2.19	1.03	0.79	1.08	0.27	1.32	0.001	1.28	0.59	1.81	0.79	0.53	0.73	0.15	0.91	0.003	0.366
Dh first molar distal root	1.54	0.69	1.75	0.66	0.21	0.69	−0.12	0.55	0.295	1.41	0.43	2.38	2.59	0.96	2.52	−0.33	2.26	0.006	0.178
Fn canine	0.13	0.56	0.29	1.03	0.16	1.08	−0.37	0.55	0.655	0.22	0.43	0.58	0.72	0.36	0.49	0.11	0.62	0.012	0.006
Fn first premolar	0	0	0	0	0	0	0	0	NA	0.28	0.71	0.10	0.28	−0.18	0.76	−0.57	0.21	0.465	NA
Fn Second premolar	0	0	0	0	0	0	0	0	NA	0.29	1.01	0.12	0.36	−0.17	1.05	−0.71	0.37	>0.999	NA
Fn first molar mesial root	0	0	0	0	0	0	0	0	NA	0	0	0.27	0.66	0.27	0.65	−0.07	0.61	0.109	NA
Fn first molar distal root	0	0	0	0	0	0	0	0	NA	0	0	0.99	0.28	0.09	0.28	−0.05	0.24	0.180	NA
3-3 width	25.29	2.16	27.57	1.23	2.28	1.74	1.45	3.12	<0.001	25.88	2.98	27.25	1.52	1.36	2.13	0.27	2.46	0.019	0.350
4-4 width	32.80	2.08	35.33	1.35	2.53	2.24	1.45	3.61	0.002	33.40	3.10	35.50	1.88	2.16	1.72	1.27	3.05	0.001	0.350
5-5 width	38.21	2.33	41.13	1.38	2.90	2.49	1.72	4.12	0.002	38.44	4.02	41.63	2.25	3.19	2.18	2.08	4.32	<0.001	0.987
6-6 width	44.48	2.26	45.43	2.05	0.95	2.25	−0.14	2.03	0.006	44.93	3.18	46.20	2.50	1.27	1.26	0.62	1.92	0.002	0.476

CI, Confidence interval; *SD*, standard deviation; *NA*, not available.

Table III. Absolute frequency and percentage of dehiscences (Dh >2 mm) and fenestrations (Fn >2.2 mm) before and after treatment

	Group 1 (n = 19)											*Group 2 (n = 17)*										
		Dehiscences					*Fenestrations*						*Dehiscences*					*Fenestrations*				
		T0		*T1*		*T1−T0*	*T0*		*T1*		*T1−T0*		*T0*		*T1*		*T1−T0*	*T0*		*T1*		*T1−T0*
	Total	*n*	*%*	*n*	*%*	*%*	*n*	*%*	*n*	*%*	*%*	*Total*	*n*	*%*	*n*	*%*	*%*	*n*	*%*	*n*	*%*	*%*
Canine	38	7	18.42	13	34.21	15.79	1	2.63	1	2.63	0.00	34	3	8.82	11	32.35	23.53	0	0.00	0	0.00	0.00
First premolar	38	9	23.68	15	39.47	15.79	0	0	0	0	0	34	8	23.53	13	38.24	14.71	1	2.94	0	0.00	−3
Second premolar	38	5	13.16	8	21.05	7.89	0	0	0	0	0	34	2	5.88	8	23.53	17.65	2	5.88	0	0.00	−6
First molar mesial root	38	1	2.63	12	31.58	28.95	0	0	0	0	0	34	1	2.94	7	20.59	17.65	0	0.00	0	0.00	0.00
First molar distal root	38	3	7.89	6	15.79	7.89	0	0	0	0	0	34	1	2.94	5	14.71	11.76	0	0.00	0	0.00	0.00
Total	190	25	13.16	54	28.42	15.26	1	0.53	1	0.53	0.00	170	15	8.82	44	25.88	17.06	3	1.76	0	0.00	−1.76

T1−T0 between both groups, no statistically significant difference was found (Table II).

No statistically significant association was found between the amount of buccolingual inclination and the increase of dehiscences for the 2 groups (Table V). Similarly, the changes for transversal width were also not significantly correlated with the increase in dehiscences for both groups (Table VI). However, changes in the transversal width are statistically significantly associated with the increase in buccolingual inclination observed at the canines, first premolars, and second premolars (Table VII).

DISCUSSION

In this study, the measurements of bone defects were performed by 2 previously calibrated observers, and the intra- and interobserver ICCs showed respectively excellent repeatability and reproducibility. In recent years, more adult patients are seeking orthodontic treatment. Because alveolar bone defects tend to increase with age, and adult patients are more susceptible to develop dehiscences and fenestrations after orthodontic treatment,[16] this study evaluated the effect of piezocision on the periodontium of the mandibular lateral buccal segments. Because piezocision is a surgical procedure designed to help achieve rapid orthodontic tooth movement by a piezoelectric flapless bone injury and a transient demineralization of the alveolar bone,[4] this study investigated whether bone defects, transverse dimensions, and buccolingual inclination of the mandibular lateral segments were different when we compared orthodontic treatment with and without piezocision.

The present study found statistically significant increases from T0 to T1 regarding dehiscences at the canines, premolars, and molars after accelerated tooth movement, with and without piezocision with the same orthodontic appliance. A very small, 0.36 mm on average, but statistically significant increase in fenestrations between T0 and T1 was observed for the canines in the experimental group. However, such small changes in fenestrations may not be clinically significant. These results are in conflict with the findings of Charavet et al,[9] who evaluated the effect of piezocision in the periodontium compared with a control group and found no significant increases in dehiscence or fenestration in either group, from baseline to the completion of treatment. In the present study, there were no statistically significant differences between groups when comparing the changes T1−T0 for dehiscences and fenestrations. These results do not agree with the findings of Vercellotti et al,[17] who found in a dog model that a piezoelectric knife provided more favorable osseous repair and also

Table IV. Treatment outcome comparison of each tooth inclination in the mandibular lateral segments between groups 1 (control) and 2 (piezocision)

	Group 1 (n = 19)		*Group 2 (n = 17)*		*T1−T0 (group 1 vs 2)*
	T1-T0		*T1-T0*		*Mann-Whitney test*
Inclination (°)	*Mean*	*SD*	*Mean*	*SD*	P *value*
Canine	2.23	2.50	2.80	2.24	0.247
First premolar	4.90	2.60	4.90	2.90	0.862
Second premolar	6.74	2.60	6.80	4.20	0.887
First molar	1.16	2.15	0.66	2.19	0.912

CI, Confidence interval; *SD*, standard deviation.

Table V. Pearson correlation coefficient between buccolingual inclination and Dh for the 2 groups

Variables	*Pearson correlation*	P *value*
Canine	−0.139	0.429
First premolar	0.114	0.508
Second premolar	0.263	0.121
First molar	0.076	0.66

Table VI. Pearson correlation coefficient between transversal width and Dh for the 2 groups

Variables	*Pearson correlation*	P *value*
Canine	0.086	0.616
First premolar	0.279	0.100
Second premolar	0.286	0.910
First molar	−0.136	0.429

bone gain in the treated side. In contrast, the results of the current study confirm findings in the literature showing that buccal bone thickness in the mandibular lateral segments[18] significantly decrease after orthodontic treatment with self-ligated brackets, showing that the piezocision had no significant influence on changes in the mandibular buccal bone defects.

In our study, both control and piezocision groups showed small increases in buccal inclination after treatment. However, no statistically significant difference was found between the groups. These results are consistent with those of Abbas et al,[11] although they evaluated the effect of piezocision on the inclination after maxillary canine distalization. In contrast, these findings contradict those reported by Verna et al,[19] who concluded, after conducting a finite element study, that surgical interventions may influence not only the amount of tooth movement but also its type. Verna et al[19] suggested that the transitory osteopenia generated by the injury to accelerate tooth movement would allow the shift of the center of rotation of the movement more apically, favoring larger tooth movement for the corticotomized tooth especially for the uncontrolled tipping.

In the present study, both groups showed smaller than 2.5° average changes in buccal inclination in the canines and first molars, and a larger buccal inclination in premolars, in average approximately 5° in the first premolars and 7° in the second premolars; indicating that, in both groups, the changes in transverse dimension in the canine and molar region were likely due to tooth body movement, and in the premolar region were likely due to tooth tipping movement. Although the study of Verna et al[19] was performed on a finite element model of a central and lateral mandibular incisor, it is the only one that evaluated the effect of reduced bone density caused by surgical interventions on the magnitude and type of orthodontic tooth movement. Fu et al[20] conducted a systematic review to evaluate the effect of various types of minimally invasive surgery, including piezocision on the plaque index, gingival recession, gingival index, attachment level, and probing depth. They did not find a significant difference between the groups. Our study complements those results, as it provides additional clinical information about the safety of the piezocision. As the studies included in the systematic review were highly heterogenous in their approaches and radiographic assessments, the authors concluded that there is only low-quality evidence to prove that flapless corticotomy could accelerate tooth movement. Our present study complements those results,[20] as it provides additional clinical information about the safety of a carefully controlled protocol for piezocision.

Table VII. Pearson correlation coefficient between transversal width and buccolingual inclination for the 2 groups

Variables	*Pearson correlation*	P *value*
Canine	0.382	0.021[*]
First premolar	0.488	0.003[†]
Second premolar	0.488	0.003[†]
First molar	0.298	0.077

[*] Correlation is significant at the 0.05 level; [†] Correlation is significant at the 0.01 level.

This study is the first to assess changes in transverse dimensions in the mandibular lateral buccal segments of patients treated with piezocision. The study findings revealed that arch width significantly increased for both groups after treatment. However, no statistically significant difference was found between the groups. These results are similar to those of Aksakalli et al,[12] who did not find any intercanine maxillary transversal differences between the control and the piezocision group when retracting canines after premolar extraction.

Several studies have indicated that the buccal inclination of the posterior teeth is associated with the increase in bone defects such as dehiscences after orthodontic treatment,[21] and that the height of the alveolar ridge can decrease after the transverse expansion during the alignment of the arches, especially in adult patients.[8,16] The present study finds a positive association between dehiscences with the buccal inclination and transversal width, especially for the first and second premolars; however, these correlations were not statistically significant. We did find a significant correlation between transversal width and buccal inclination at the canines and a highly significant correlation at the first and second premolars, which may indicate that the majority of the arch expansion was achieved by buccal inclination in the premolar region, considering that the last archwire used in the mandible was a 0.017 × 0.025-in stainless steel and the 0.019 × 0.025-in stainless steel was not used. This study's findings are in conflict with

Birnie's review of the literature[22] on self-ligating brackets, who reported that transverse changes during alignment occur through body movement of the buccal lateral segments, with a minimum inclination of the premolars. Our findings of a positive association between transversal changes and buccal inclination of the premolars are consistent with Cattaneo et al,[23] although they evaluated the quantity and type of tooth movement of maxillary lateral segments achieved with self-ligating bracket systems, they also showed that the transversal expansion was achieved by buccal tipping in the premolar region.

The CBCT scans in this study allowed the quantitative evaluation of dehiscences and fenestrations in patients, without the need for an invasive procedure such as a flap elevation for a direct assessment. Although the radiation exposure for conventional radiographs is lower than for the CBCT scans, its resolution does not provide the precise reproduction of the periodontium anatomic details.[24] Furthermore, CBCT has shown an acceptable diagnostic value for detecting alveolar bone dehiscences and fenestrations with also acceptable sensitivity and specificity.[13,14] However, the concerns of increased radiation dose using CBCT have been discussed in different guidelines to orient clinicians on how to prescribe CBCT exams.[25,26] It is important to highlight that the CBCT used for the analysis were not acquired for the purpose of the present study. The available scans had been acquired adjusting parameters to reduce ionizing radiation effects following the as low as diagnostically acceptable principles.[27]

Considering that Wilcko et al[28] showed in CBCT scans of 2 patients who received surgically accelerated orthodontic treatment without bone grafting that after 2 years of retention, there appears to be a recovery of the alveolar bone comparable to the pretreatment, further research is needed to evaluate the long-term effect of the orthodontic treatment with piezocision on the buccal bone surface.

CONCLUSIONS

In general, there were no significant differences in buccal dehiscences and transversal tooth movement (buccolingual inclination and arch width) of mandibular lateral segments between patients after orthodontic treatment with and without piezocision. An increase in dehiscences, buccal inclination, and arch width from T0 to T1 was observed in both groups. There were no significant correlations between the amount of buccolingual inclination and dehiscences. There were no significant correlations between the transversal width changes and dehiscences. The changes in the transversal width are statistically significantly associated with the increase in buccal inclination at the canines, first and second premolars.

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