Periodontal Effect of Periodontally Accelerated Osteogenic Orthodontics in Skeletal Angle Class III: A Nonrandomized, Controlled Trial

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The objective of this study was to evaluate the effect of periodontally accelerated osteogenic orthodontics (PAOO) on gingivae and alveolar bone by analysis of clinical and cone beam computed tomography (CBCT) parameters in the treatment of 20 skeletal Class III patients. The patients included in this study were divided into test and control groups. Periodontal parameters such as probing depth (PD), gingival recession (GR), keratinized gingival width, and alveolar bone thickness of CBCT scans were measured and recorded preoperation (T0) and at 6 months postoperative (T1). The difference in PD from T0 to T1 between the two groups was not statistically significant (0.01 ± 0.46 mm vs 0.22 ± 0.65 mm, respectively; $P > .05$). No significant difference in GR was observed from T0 to T1 between the two groups (0.03 ± 0.26 mm vs –0.03 ± 0.27 mm, respectively; $P > .05$). Alveolar bone thickness (4 mm apical to the cementoenamel junction [CEJ]) change from T0 to T1 was –0.31 ± 0.35 mm for the control group and 0.06 ± 0.69 mm for the test group ($P < .05$). Meanwhile, alveolar bone thickness (6 mm apical to CEJ) changes from T0 to T1 were –0.38 ± 0.54 mm and 0.10 ± 0.80 mm for the control and test groups, respectively ($P < .05$). It was determined that PAOO in the treatment of skeletal Class III patients is effective and safe to periodontium on the basis of clinical and CBCT parameters. Int J Periodontics Restorative Dent 2020;40:e169–e177. doi: 10.11607/prd.4545

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Currently, many adult patients are in need of orthodontic treatment in China. Unfortunately, some patients do not want this time-consuming treatment, especially Angle Class III patients, who need an interdisciplinary approach that includes orthodontic and orthognathic treatment. In preparation for orthognathic treatment, removal of dentoalveolar compensation for skeletal deformity is required to ideally put the jaw in a harmonious relationship. As a result, the profile will become more unacceptable to the patients after presurgical orthodontic treatment, and the entire interdisciplinary treatment time will exceed 3 years. Therefore, clinicians need a method to accelerate the orthodontic treatment of these patients. In 1959, Kole[1–3] developed the idea of using corticotomy to accelerate orthodontic tooth movement. Murphy et al[4] and Wilcko et al[5,6] more recently proposed the concept of PAOO (Periodontally Accelerated Osteogenic Orthodontics) to accelerate orthodontic treatment by elevating the full-thickness flap and using a bur or piezoelectric knife to create the cortical bone incision.

Some clinical studies have indicated that the use of PAOO is effective and safe.[4–15] However, most of the studies are case reports, and there is a lack of systematic prospective controlled clinical studies to prove PAOO is safe to the periodontium. Because of dentoalveolar compensation for the skeletal deformity, the labial gingivae and the labial alveolar bone of anterior teeth of skeletal Angle Class III patients were thinner than other malocclusion patients,[16–18] which may increase the periodontal risk (gingival recession, esthetic failure, alveolar bone loss, dehiscences, and fenestrations) of PAOO. As a result, clinicians need to pay more attention to the safety of PAOO on the gingivae and alveolar bone of skeletal Angle Class III patients. The objective of this study was to evaluate the effect of PAOO on gingivae and alveolar bone by analysis of cone beam computed tomography (CBCT) and clinical parameters of periodontics in the treatment of skeletal Class III patients.

Materials and Methods

Patient Selection

The Peking University Ethics Committee and Competent Authority approved the clinical study before it began (No. PKUSSIRB-2012052). The clinical trial registration number is ChiCTR-ONRC-13004129. All patients were given information about the treatment of this study and signed consent forms. The 20 patients included in this study (14 women and 6 men, ages 18 to 30 years) presented for orthodontic or orthognathic consultation at Peking University School and Hospital of Stomatology from 2013 to 2016. Inclusion criteria were as follows: *(1)* age 18 to 40 with good systemic health; *(2)* ANB (A point–nasion–B point) angle less than –5 degrees; *(3)* good periodontium health; and *(4)* extraction of the maxillary first premolar bilaterally before orthodontic treatment. Exclusion criteria were as follows: *(1)* pregnancy; *(2)* systemically unhealthy with tumor or metabolic disease; *(3)* oral and maxillofacial acute inflammation or tumor; *(4)* moderate to severe periodontitis or uncontrolled light periodontitis; *(5)* congenital cleft palate or cleft lip; and/or *(6)* severe oral and maxillofacial asymmetry.

Surgical and Orthodontic Procedures

PAOO is a concept of interdisciplinary treatment including orthodontic treatment and modified piezoelectric corticotomy. After inclusion in the study, patients were divided into either the test or control group, according to their intention. The 10 patients who accepted PAOO to accelerate closure of the extraction space were involved in the test group, while others were included in the control group. The same orthodontist (J.H.J.) proposed that all patients receive fixed orthodontic treatment. Before closing the interdental space, the teeth were leveled and aligned, and then a periodontist (the same for all patients in the test group; D.L.) performed the piezoelectric corticotomy. Closing of the interdental space began 2 weeks postoperation. After finishing the closure of the space, orthognathic surgery was performed by the same surgeon (C.L.) (Le Fort I osteotomy, bilateral sagittal split ramus osteotomy, or genioplasty). Orthodontic treatment was performed again postoperatively. Patients in the control group only received fixed orthodontic treatment and orthognathic treatment without any periodontal surgery.

First, prophylaxis scaling was needed. Periodontal surgery was performed with loupes (53-20, ×2.5 – ×3.5; Zeiss) before closure of the interdental space. After local anesthesia had been administered, a microsurgical blade was used to make crevicular, horizontal, and vertical incisions on the buccal aspect (second premolar to second premolar), edentulous area of the first premolar, and distobuccal area of the second premolar, respectively. Full-thickness flaps were elevated, and a piezosurgical knife (BS1, Piezotome, Acteon) was used to create the vertical interproximal cortical bone incisions below the alveolar bone crest to a depth of 2 to 3 mm. Tricalcium phosphate (TCP) bone substitute (Cerasorb, Curasan) was grafted on the buccal aspects of the anterior cortical bone, dehiscence, and fenestration, coronally to the apical level. Labial frenectomy was performed when needed. Flaps were coronally repositioned, and single sling sutures and interrupted interdental sutures were made using nonresorbable 5-0 sutures (Prolene, Ethicon US). Amoxicillin and chlorhexidine were recommended for 1 week after surgery. Ibuprofen was used when needed. Sutures were removed 1 week postoperatively and patients were able to resume orthodontic treatment 2 weeks after surgery (Fig 1).

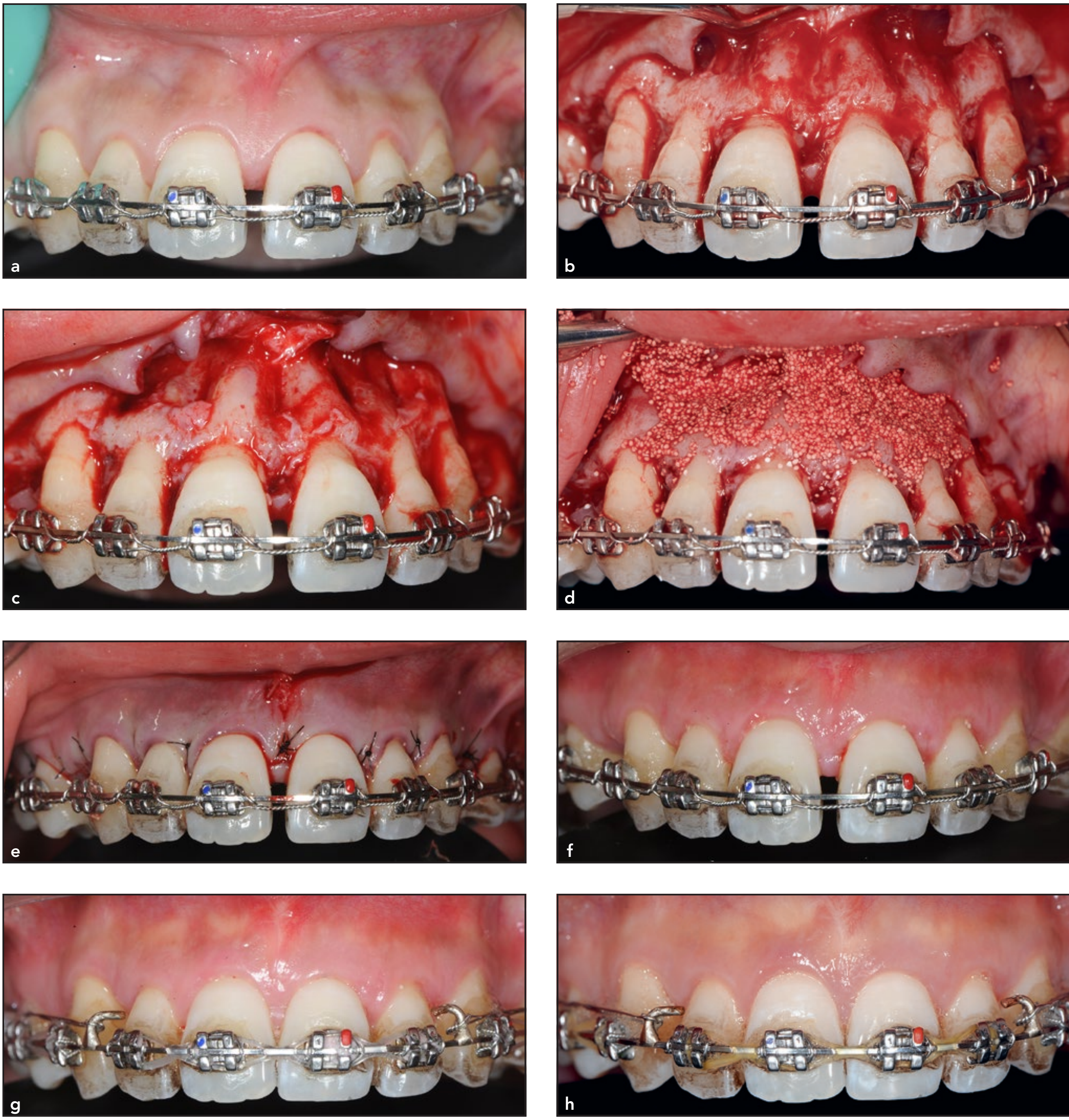

Fig 1 *Test group patient.* (a) *Before periodontal surgery.* (b) *Full-thickness flaps were elevated.* (c) *Vertical interproximal cortical bone incisions were created using a piezosurgical knife.* (d) *Bone was grafted on the labial aspect of cortical bone.* (e) *The flaps were coronally repositioned and sutured. Clinical views at* (f) *2 weeks,* (g) *1 month, and* (h) *2 months postoperation.*

Clinical and CBCT Parameters

Measurement time points before orthognathic surgery included the following:

- T0: Before periodontal surgery, after aligning and leveling the maxillary teeth
- T1: Six months after periodontal surgery

Clinical parameters such as probing depth (PD), keratinized gingival width (KGW), and gingival recession (GR) were measured before and after periodontal surgery in

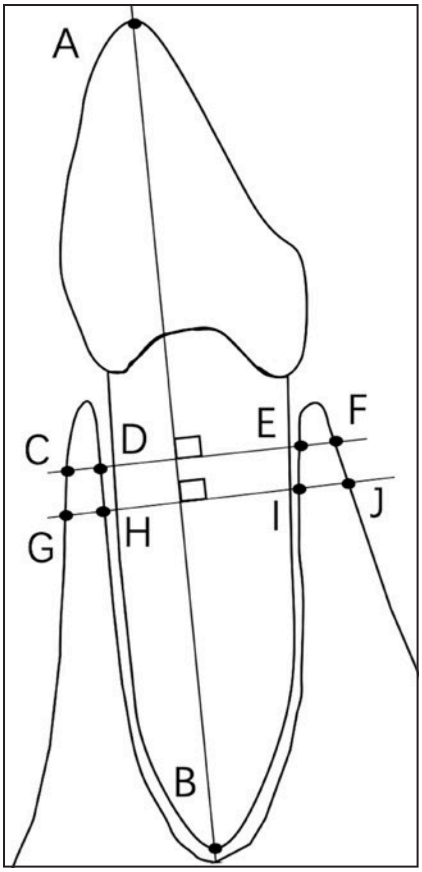

Fig 2 *Illustration of measurements and reference points used in this study. A = coronal apex point; B = apical apex point; AB = long axis of the tooth; C to D = labial alveolar bone thickness at 4 mm apical to the CEJ, perpendicular to the long axis of the tooth; E to F = palatal alveolar bone thickness at 4 mm apical to the CEJ; G to H = labial alveolar bone thickness at 6 mm apical to the CEJ; I to J = palatal alveolar bone thickness at 6 mm apical to the CEJ.*

the test and control groups. CBCT scans were taken using NewTom VG (Aperio Services) at T0 and T1. OsiriX v. 3.9.2 (Pixmeo SARL) was used to perform visual analyses. After three-dimensional reconstruction, the images were oriented in three planes to measure alveolar bone horizontal thickness at 4- and 6-mm levels apical to the cementoenamel junction (CEJ). All parameters were measured at T0 and T1 in both groups, and the difference (T1 – T0) was recorded. Alveolar bone horizontal thickness measurements were recorded perpendicular to the long axis of the teeth and were made to the limit of the buccal and palatal cortical surfaces at 4- and 6-mm levels apical to the CEJ. All measurements and reference points used in this study are presented in Fig 2.

Statistical Analysis

All clinical examinations were performed by the same periodontist (X.X.) and calibrated by kappa value (between 0.8 and 0.9). Every measurement of the CBCT was repeated after 1 week by the same researchers (X.X. and W.D.J.), and intraexaminer error was tested using paired *t* test. The intraclass correlation coefficient was used to evaluate the magnitude of the measurement error. The mean of the two measurements was used in the study. Nonparametric tests were used for statistical analysis. $P < .05$ was chosen to indicate significance for all tests.

Results

Ten patients (2 men and 8 women, ages 18 to 30 years) with 60 maxillary anterior teeth were included in the test group, while 10 patients with 59 maxillary anterior teeth (4 men and 6 women, ages 18 to 30 years) were included in the control group. No severe discomfort or swelling was reported postoperatively, with minimal impact on chewing, pronunciation, and esthetics. The intraexaminer error was not statistically significant ($P > .05$), and the mean intraclass correlation coefficient was above 0.90. The means and standard deviations (SDs) for PD, KGW, and GR measurements in the test and control groups are presented in Table 1. The means and SDs for alveolar bone thickness measurements at 4 mm and 6 mm are presented in Tables 2 and 3, respectively.

Clinical Parameter Changes

The PD measurements (mean ± SD) for the control and test groups at T0 were 2.28 ± 0.40 mm and 1.93 ± 0.47 mm, respectively. At T1, the control- and test-group PD measurements were 2.29 ± 0.44 mm and 2.14 ± 0.58 mm, respectively. The difference in PD between the control and test groups (0.01 ± 0.46 mm vs 0.22 ± 0.65 mm, respectively) was not statistically significant ($P > .05$).

Table 1 Comparison of PD, KGW, and GR Measurements and Differences Between the Control and Test Groups

	PD, mm			KGW, mm			GR, mm		
	Control group	Test group	*P*	Control group	Test group	*P*	Control group	Test group	*P*
T0	2.28 ± 0.40	1.93 ± 0.47	< .001	5.30 ± 1.34	5.72 ± 0.99	.061	0.02 ± 0.13	0.13 ± 0.42	.054
T1	2.29 ± 0.44	2.14 ± 0.58	.096	5.55 ± 1.22	6.07 ± 0.85	.04	0.05 ± 0.39	0.09 ± 0.41	.332
Difference (T1 – T0)	0.01 ± 0.46	0.22 ± 0.65	.14	0.25 ± 0.87	0.35 ± 0.77	.799	0.03 ± 0.26	–0.03 ± 0.27	.251

PD = probing depth; KGW = keratinized gingival width; GR = gingival recession; T0 = before periodontal surgery; T1 = 6 months after periodontal surgery.
Data are presented as the mean ± standard deviation. The control group comprised 59 anterior teeth and the test group comprised 60 anterior teeth.

Table 2 Comparison of ABT (4 mm Apical to the CEJ) Measurements and Differences Between the Control and Test Groups

	LaABT4			PABT4			ABT4		
	Control group	Test group	*P*	Control group	Test group	*P*	Control group	Test group	*P*
T0	0.94 ± 0.33	0.49 ± 0.34	< .001	1.19 ± 0.55	0.88 ± 0.58	.024	1.06 ± 0.47	0.69 ± 0.51	< .001
T1	0.65 ± 0.30	0.54 ± 0.35	.084	0.85 ± 0.56	0.96 ± 1.01	.812	0.75 ± 0.46	0.75 ± 0.78	.174
Difference (T1 – T0)	–0.29 ± 0.23	0.04 ± 0.46	< .001	–0.34 ± 0.44	0.08 ± 0.87	.005	–0.31 ± 0.35	0.06 ± 0.69	< .001

ABT = alveolar bone thickness; CEJ = cementoenamel junction; LaABT4 = labial ABT at 4 mm apical to the CEJ; PABT4 = palatal ABT at 4 mm apical to the CEJ; ABT4 = mean ABT at 4 mm apical to the CEJ; T0 = before periodontal surgery; T1 = 6 months after periodontal surgery.
Data are presented as the mean ± standard deviation. The control group comprised 59 anterior teeth and the test group comprised 60 anterior teeth.

Table 3 Comparison of ABT (6 mm Apical to the CEJ) Measurements and Differences Between the Control and Test Groups

	LaABT6			PABT6			ABT6		
	Control group	Test group	*P*	Control group	Test group	*P*	Control group	Test group	*P*
T0	0.81 ± 0.37	0.46 ± 0.36	< .001	1.94 ± 0.80	1.74 ± 1.05	.222	1.38 ± 0.84	1.10 ± 1.01	.001
T1	0.59 ± 0.26	0.42 ± 0.27	.001	1.41 ± 0.95	1.98 ± 1.36	.018	1.00 ± 0.80	1.20 ± 1.26	.616
Difference (T1 – T0)	–0.22 ± 0.28	–0.04 ± 0.35	.001	–0.53 ± 0.68	0.25 ± 1.06	< .001	–0.38 ± 0.54	0.10 ± 0.80	< .001

ABT = alveolar bone thickness; CEJ = cementoenamel junction; LaABT6 = labial ABT at 6 mm apical to the CEJ; PABT6 = palatal ABT at 6 mm apical to the CEJ; ABT6 = mean ABT at 6 mm apical to the CEJ; T0 = before periodontal surgery; T1 = 6 months after periodontal surgery.
Data are presented as the mean ± standard deviation. The control group comprised 59 anterior teeth and the test group comprised 60 anterior teeth.

The KGW measurements (mean ± SD) of the control and test groups were 5.30 ± 1.34 mm and 5.72 ± 0.99 mm, respectively, at T0, and were 5.55 ± 1.22 mm and 6.07 ± 0.85 mm, respectively, at T1. The difference in KGW measurements between the control and test groups (0.25 ± 0.87 mm vs 0.35 ± 0.77 mm, respectively) was not statistically significant ($P > .05$).

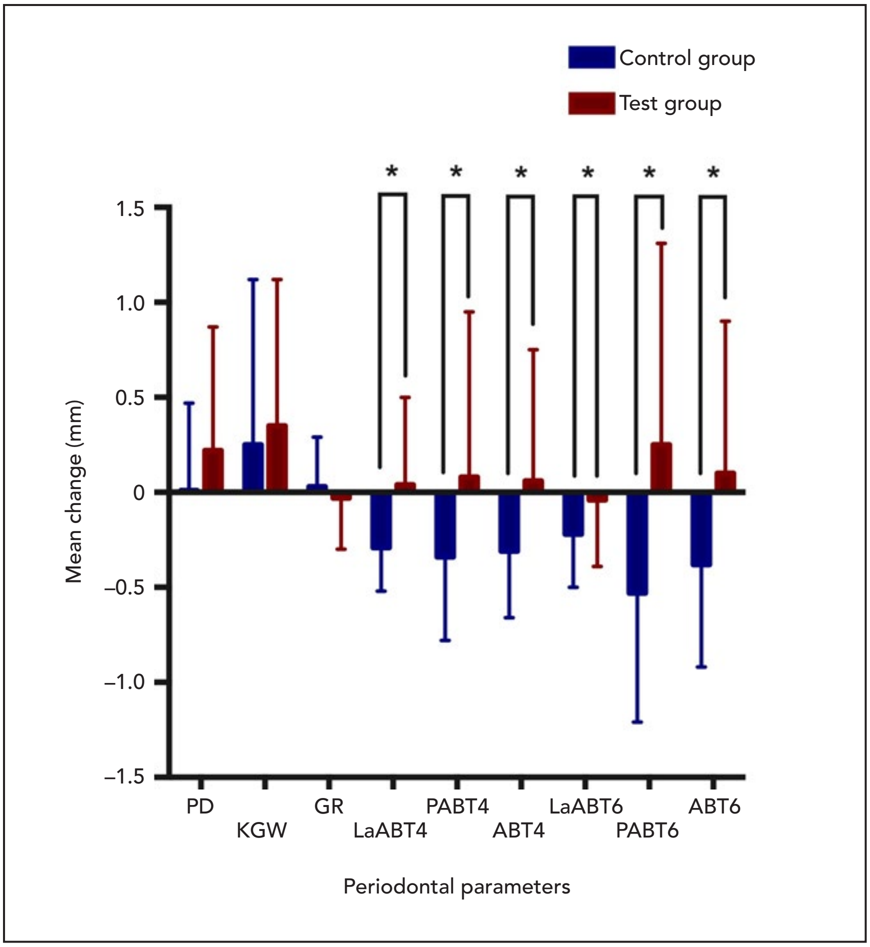

Fig 3 *Comparison of mean changes (T1 – T0) in PD, KGW, GR, and labial (La) and palatal (P) alveolar bone thickness (ABT) at 4 and 6 mm between the test and control groups. *Statistically significant (P < .05).*

The GR measurements (mean ± SD) of the control and test groups were 0.02 ± 0.13 mm and 0.13 ± 0.42 mm, respectively, at T0, and were 0.05 ± 0.39 mm and 0.09 ± 0.41 mm, respectively, at T1. The difference of GR measurements between the control and test groups (0.03 ± 0.26 mm vs –0.03 ± 0.27 mm, respectively) was not statistically significant ($P > .05$).

Alveolar Bone Horizontal Thickness Changes

At 4 mm Apical to the CEJ

The changes (T1 – T0) in labial alveolar bone thickness were –0.29 ± 0.23 mm and 0.04 ± 0.46 mm for the control and test groups, respectively ($P < .05$). The palatal alveolar bone thickness changes were –0.34 ± 0.44 mm and 0.08 ± 0.87 mm in the control and test groups, respectively ($P < .05$). Compared to T0, the alveolar bone thickness of control group decreased while the bone thickness of the test group slightly increased, and the differences between the two groups were statistically significant ($P < .05$).

At 6 mm Apical to the CEJ

The changes (T1 – T0) in labial alveolar bone thickness were –0.22 ± 0.28 mm and –0.04 ± 0.35 mm in the control and test groups, respectively ($P < .05$). The palatal alveolar bone thickness changes were –0.53 ± 0.68 mm and 0.25 ± 1.06 mm in the control and test groups, respectively ($P < .05$). Compared to T0, the alveolar bone thickness of control group decreased while the bone thickness of the test group slightly increased, and the differences between the two groups were statistically significant ($P < .05$).

A comparison of test- and control-group changes (T1 – T0) in PD, KGW, GR, and labial and palatal alveolar bone thicknesses at 4 and 6 mm is presented in Fig 3. CBCT images of anterior teeth in the test group are shown in Fig 4.

Discussion

Murphy et al[4] and Wilcko et al[5,6] proposed the concept of PAOO to accelerate orthodontic treatment by elevating a full-thickness flap and using a bur to create the cortical bone incision. Beginning in 2009, Dibart et al,[7–10] along with other researchers, improved the procedure, making the surgery less invasive

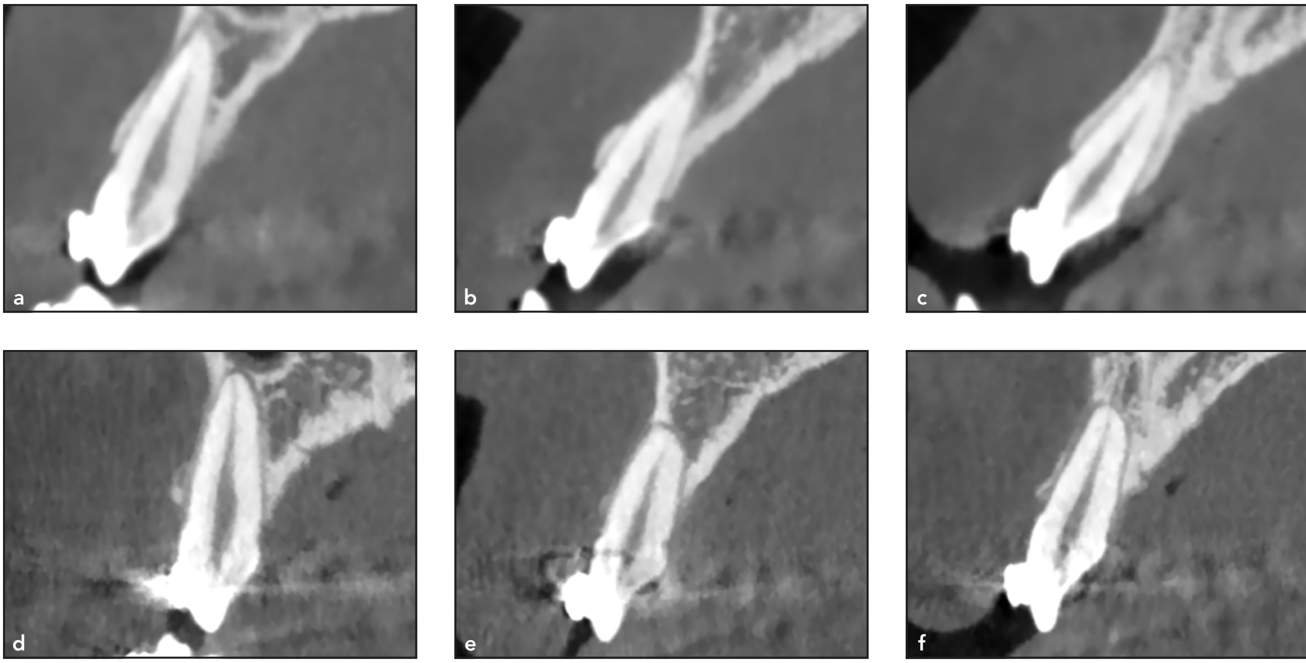

Fig 4 *CBCT images of maxillary anterior teeth on the labial-palatal plane in a test-group patient. Labial alveolar bone is thin before periodontal surgery at* (a) *tooth 13,* (b) *tooth 12, and* (c) *tooth 11 (FDI system). Labial alveolar bone was maintained at* (d) *tooth 13,* (e) *tooth 12, and* (f) *tooth 11 6 months after the procedure and orthodontic treatment.*

with Piezocision (combining microincisions with cortical incisions by a piezoelectric knife). In 2015, Wu et al[12] came up with the concept of improved AOO treatments, in which orthodontic treatment is accelerated by elevating a full-thickness flap and using a piezoelectric knife to create the cortical bone incision, and the study preliminarily proved this method to be less time-consuming.

This clinical longitudinal research study was designed to evaluate the effect of PAOO on gingivae and alveolar bone thickness by analyzing CBCT scans and clinical periodontal parameters in the treatment of skeletal Class III patients. The follow-up period was 6 months. The control group, which included 59 maxillary teeth, could reduce the bias caused by orthodontic attachment in the analysis. The PAOO's corticotomy procedure combines the piezoelectric knife, elevated flap, and bone graft, referred to as a modified piezoelectric corticotomy. Before closing the interdental space, the teeth were leveled and aligned; a periodontist (the same for all patients in the test group; L.X.) then performed the piezoelectric corticotomy to accelerate closure of the interdental space. The advantages of this procedure are reductions in the difficulty of the operation, as well as risk of gingivae and root damage. The procedure is more minimally invasive with loupes and microsurgical instruments. Additionally, use of a piezoelectric knife can make the corticotomy more comfortable and acceptable, without severe postoperative discomfort and high morbidity. TCP is an osteoconductive and resorbable substitute that contributes to bone formation and bone remodeling without a negative effect on orthognathic surgery. Bone graft is used to maintain alveolar bone thickness and decrease the periodontal risks (esthetic failure and alveolar bone loss) in rapid orthodontic teeth movement, especially for labial gingivae and alveolar bone of maxillary teeth, which refers to the esthetic zone. In the present study, the labial alveolar bone is thinner than the palatal bone, indicating a greater periodontal risk for labial gingivae and alveolar bone. As a result, bone grafting was performed on the labial side (instead of on both sides) with less invasive measures.

Wu et al's clinical study[12] on the improved accelerated osteogenic orthodontics included 24 samples, which were equally divided into two groups. As a result, the duration of the entire presurgical orthodontic procedure was significantly reduced by 6.39 ± 2.00 months in the improved AOO group. These results indicated that the improved AOO could reduce the surgical orthodontic treatment time for skeletal Class III surgical patients by more than half a year on average.

In the present study, no severe discomfort or swelling was reported postoperatively, with minimal impact on chewing, pronunciation, and esthetics, which was similar to other research[19,20] and was owed to the use of loupes, microsurgical instruments, and a piezoelectric knife. These results suggest that the modified piezoelectric corticotomy is minimally invasive, clinically acceptable, and comfortable (no severe discomfort or high morbidity). In terms of changes in clinical parameters, the oral hygiene of all patients was generally good before and after the surgery, with no gingival inflammation. As a result, all periodontal parameters remained stable, and no significant differences (T1 – T0) were observed for PD, KGW, or GR between the two groups. PAOO did not lead to gingival inflammation, attachment loss, or gingival recession. All results reported herein are similar to other studies.[4–10,20]

Six months after periodontal surgery, the KGW was greater than the preoperative width in both groups, which is attributable to an increase in patient age and retraction of the anterior teeth. Although the postoperative width was greater at 6 months, the changes in both groups were less than 0.5 mm and were not statistically significant between groups. Therefore, PAOO had few effects on gingival width.

In Wu et al's clinical study,[21] root resorption was minimal after improved AOO. According to the Sharpe scoring system, root resorption scores in the most anterior teeth of improved AOO were 1, which suggests that improved AOO has few effects on root resorption.

The present study chose two levels to measure for alveolar bone thickness (4 and 6 mm below the CEJ) because they were in the middle of the cortical bone incisions. According to Mandelaris et al,[22] the alveolar bone can be divided into two parts along the 4-mm level below the CEJ: the crest and apical zones. Therefore, the two levels in the present study are more representative of the alveolar bone thickness changes than just one level.

Retraction of the teeth and removal of dentoalveolar compensation for skeletal deformities are the main reasons for the control group's decrease in bone thickness.[23,24] Alternatively, the test group's alveolar bone thickness remained stable at 4 and 6 mm because of TCP bone grafting. The labial alveolar bone thickness was less than 1.2 mm in both groups and the bone of lateral incisors was the thinnest, which is similar to the findings of Zhou et al.[25] The labial movement of the root will lead to the loss of the apical alveolar bone thickness. If the root is predominant, the bone substitute will not be stable to promote bone augmentation. In general, the PAOO does not damage the alveolar bone, and the bone graft will let the bone remain stable and reduce the risk of fenestration and dehiscence. All results were similar to the case reports of Murphy et al,[4] Wilcko et al,[5,6] and various other clinical studies.[13–15,21]

The duration of the study follow-up was 6 months, and the sample size was relatively small. Therefore, one should use caution when discussing the results and drawing conclusions due to these limitations. The sample size and the duration of the follow-up should be expanded to more conclusively prove that PAOO is safe to periodontal tissue.

Conclusions

PAOO in the treatment of skeletal Class III surgical patients is effective, safe for the periodontium, and does not negatively affect alveolar bone on the basis of clinical and CBCT parameters.

Acknowledgments

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