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Effect of a self-ligating bracket system combined with corticision on the rate of orthodontic tooth movement: A controlled clinical trial

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Abstract

BACKGROUND: The self-ligating bracket system and corticision are two methods for acceleration of orthodontic tooth movement (OTM).

OBJECTIVES: The current study aimed to assess the effect of a self-ligating bracket system combined with corticision on the rate of OTM.

PATIENTS AND METHODS: The present study was conducted on 16 female patients divided into two groups: an experimental group of eight patients treated by self-ligating bracket systems used as fixed orthodontic appliances combined with a corticision as a minimally invasive surgical technique for accelerating OTM, and a control group of eight patients treated only by self-ligating bracket systems used as fixed orthodontic appliances. The primary outcome was the percentage of change in Little's Index of Irregularity (LII). The secondary outcome was the time taken to finish the leveling and alignment stage.

RESULTS: In a comparison of the percentage of change in LII for the upper arch between the two groups, the experimental group recorded values that were significantly greater than those recorded in the control group at all time intervals T0–T7, except for T8–T10, which were similar. Both groups recorded (100 ± 0%), with no significant difference between groups ($P = 1$).

CONCLUSION: The combination of two methods for acceleration of OTM, a self-ligating bracket system combined with corticision, accelerates the rate of OTM more than in the case of using a self-ligating bracket system only.

Keywords:

Acceleration of orthodontic tooth movement, corticision, intraoral scanning for orthodontic cases, mild-to-moderate crowding, self-ligating bracket system

Introduction

Acceleration of orthodontic tooth movement (OTM) is one of basic requirements for the patient because it shortens the treatment time and is preferred by orthodontists because treatment duration has been linked to an increased risk of gingival inflammation, decalcification, dental caries, and root resorption.[1–4] The average duration of comprehensive orthodontic treatment is less than 2 years, with a mean of 19.9 months. But prolonged periods of wearing oral braces, particularly non-cosmetic appliances, tend to push patients, especially adults, to forgo treatment, even when it is clearly indicated.[5–7]

Moreover, longer treatment durations are expensive for both the patient and

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the orthodontist. Therefore, one of the best ways to overcome this problem is to increase the velocity of tooth movement from its usual rate of 0.8–1.2 mm/month (when continuous forces are applied).[8,9]

There are different approaches to the acceleration of OTM: biomechanical, physiological-mechanical, pharmacological, surgical-assisted, and surgery-simulated. Pharmacological approaches to accelerating OTM include local cytokine delivery, prostaglandin application, receptor activator of nuclear factor kappa□B ligand (RANKL), parathyroid hormone, vitamin D3, and corticosteroids.[10–14]

Physical stimuli to accelerate OTM include direct electric currents and pulsed electromagnetic fields, vibratory stimuli, and photobiomodulation. Both the pharmacological and physical approaches are considered noninvasive techniques for accelerating OTM. Also, laser acts as one of the methods for acceleration of OTM as it accelerates the tissue reaction and has a positive effect on biological response for orthodontic force.[15–17]

Surgical maneuvers to accelerate orthodontic treatment were first described in the late 1950s, when corticotomy was performed, as cortical bone was identified as the main tissue layer to resist tooth movement. Corticotomies were found to cause no damage to the pulpal tissues' blood supply or to the periodontal tissues' vitality.[18–20]

Minimally invasive surgical techniques include piezocision and corticision. Piezocision has been used successfully to correct class III malocclusion, achieved with a treatment time of 8 months and a follow-up at 15 months, which revealed only a mild relapse.[21]

Another minimally invasive surgical technique is corticision, which was proposed in 2006 by Young Guk Park and employed in experiments on cats in 2009. A reinforced scalpel was used as a thin chisel to separate the interproximal cortices transmucosally without flap reflection. Histologic analysis at day 14 revealed large resorption cavities filled with osteoclasts, which accelerated tooth movement, and the healing process was initiated at this site by day 21, suggesting a catabolic remodeling of bone with this procedure.[22,23]

The use of self-ligating brackets is a biomechanical approach that has also been claimed to enhance tooth movement. There are generally two types of self-ligating bracket systems, active and passive, with the passive type having a sliding door ligating site with no active component compressing against arch wires like that of the active type. The efficiency of self-ligating systems is believed to be due to low friction mechanics and the elimination of elastomeric and ligature ties that would lead to an increase of friction.[24,25]

The aim of the current clinical study is to assess the effectiveness of corticision as a minimally invasive technique combined with a self-ligating bracket system for the acceleration of orthodontic tooth movement.

Patients and methods

Study design

This is a prospective randomized controlled clinical study. This study was a two-arm parallel study with a 1:1 allocation ratio.

Ethical considerations

The nature of the study was explained to all patients and their parents or guardians, and consent forms were signed. The current study was approved by the Ethics Committee for Dental Research, Faculty of Dental Medicine, of the same institution of the corresponding author with number 721/271. The present study was also submitted to ClinicalTrials.gov.

Sample size calculation

Based on Abdarazik *et al*. (2020)[26] and Kim *et al*. (2009)[23] and using the G*Power statistical power analysis program (version 3.1.9.4) for sample size determination, a total sample size (n = 16; subdivided to 8 in each group) is sufficient to detect a large effect size (f) =1.26, with an actual power (1-β error) of 0.8 (80%) and a significance level (α error) of 0.05 (5%) for a two-sided hypothesis test.

Inclusion criteria

- The sample included class I orthodontic patients with mild-to-moderate crowding of the upper anterior segment (2–4 mm).
- All study participants should have all permanent teeth erupted except wisdom teeth.
- All study participants should have a good oral and general health, with no systemic disease or regular medication that could interfere or affect OTM.
- All study participants should have no previous orthodontic treatment.

Study groups

Two groups were randomly created from the sample:

The experimental group included eight female patients treated by corticision as a minimally invasive surgical technique for accelerating OTM, combined with self-ligating bracket systems as fixed orthodontic appliances.

The control group included eight female patients treated only by self-ligating bracket systems used as fixed orthodontic appliances.

Groups' randomization

The patients involved in the study groups were randomly distributed through a simple online generated randomization plan by using online software found at the website http://www.graphpad.com/quickcalcs/index.cfm. The allocation ratio is 1:1.

Orthodontic records

The following standardized orthodontic records were taken for each patient for both groups [Figure 1]:

1. Extraoral and intraoral photographs before and after orthodontic treatment;
2. Intraoral scans of the upper arch, taken before treatment (T0) and at each week in the first 6 weeks after installation of the fixed orthodontic appliance (T1, T2, T3, T4, T5, T6) and then each month until the 5th month (T7, T8, T9, T10; Figure 2);
3. Digital lateral cephalometric radiographs before and after orthodontic treatment; and
4. Digital panoramic radiographs to detect positions of roots of neighboring teeth before and after orthodontic treatment.

Treatment procedures

Experimental group

All teeth mesial to first molars in both dental arches were bonded with a self-ligating Roth's prescription preadjusted edgewise bracket system of the interactive type (USA Sheboygan, Wisconsin, SL metal bracket system, American Orthodontics, ®Empower2); then the first molars in both dental arches were bonded with Roth's prescription preadjusted buccal tubes (ifit® buccal Wisconsin, USA buccal tube, USA). Then, a light-cured orthodontic adhesive was used to bond the brackets and tubes on the labial and buccal surfaces of the teeth (BracePaste® adhesive, American Orthodontics, Sheboygan, Wisconsin, USA).

Immediately before the insertion of the first arch wire, corticision was performed as follows [Figure 3]: The interradicular distances were ascertained to be adequate for the procedure using the panoramic radiograph. Then, an antiseptic mouthwash was prescribed prior to the procedure for decreasing the probability of infections (Hexitol®, chlorhexidine hydrochloride 125 mg/100 ml, ADCO-Pharma, Egypt). A topical anesthetic agent was applied, and infiltration anesthesia solution was administered on the sites of corticision (Artinibsa® (4% articaine with 1:100000 epinephrine, Laboratorios Inibsa, S.A. Barcelona, Spain)).

Reinforced 15T scalpel blades on № 3 handles were used in the procedures (Swann Morton Ltd. Sheffield, England). The scalpel was placed on the attached gingiva between the roots of the teeth to be moved at an angle of 45°:60° to the long axis of the tooth.

A surgical mallet was used to tap the scalpel handle to gradually insert the scalpel blade into the gingiva, cortical bone, and cancellous bone, reaching the bone marrow. Attention was paid to leave about 5 millimeters of the papillary gingiva to prevent alveolar crest bone loss. Scalpel penetration was about 1 centimeter in depth and about two-thirds of the root length. The scalpel was removed with a careful swinging movement. The procedure was performed at six sites (distal to each maxillary anterior tooth). A sterile saline solution was used for irrigation till bleeding stopped.

Amoxicillin-clavulenate [625 mg tablets] was prescribed as a postoperative prophylactic antibiotic and paracetamol [500 mg tablets] as a pain killer (both twice daily). The technical steps of the aforementioned surgical procedure were dependent on the work of Young Guk Park published in 2016, "Corticision: a Flapless Procedure to Accelerate Tooth Movement".[22]

During the same visit in which corticision was performed, the first arch wire was inserted. The wire sequence was 0.013, 0.016, 0.018, 0.016x0.022, and 0.018x0.025 inch

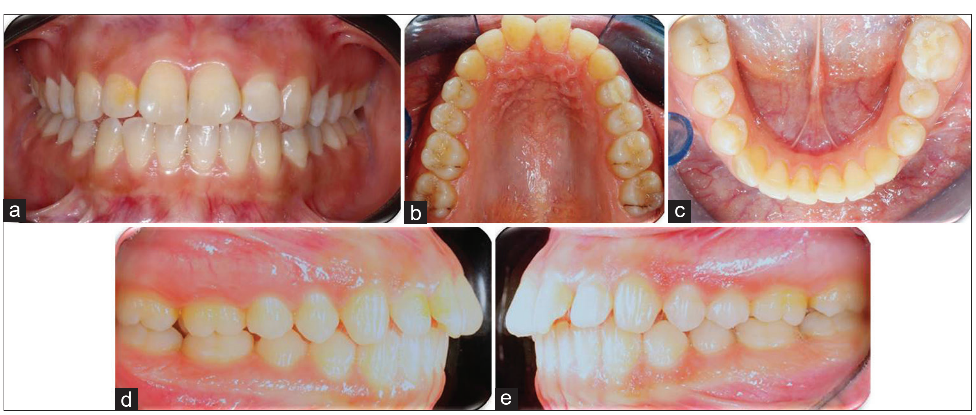


Figure 1: Pretreatment intraoral photographs for an experimental group patient (a-upper, b-frontal, c-lower, d- left lateral, e- right lateral intraoral photographs)

copper-NiTi arch wires (Tanzo® Cu-Niti wires, American Orthodontics, Sheboygan, Wisconsin, USA; Figure 4).

Control group

The same treatment protocol was used as in the experimental group, except for the corticision step; no corticision was performed in this group.

Figure 2: Digital dental model for upper teeth, fabricated on IOS software

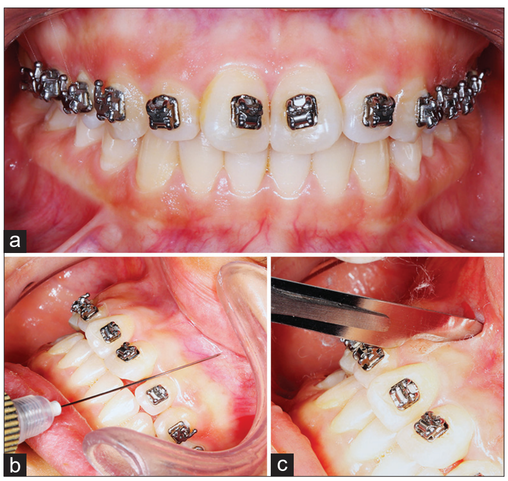


Figure 3: Surgical procedure for corticision for a sample of the experimental group (a- pre- surgery, b- anesthesia administration, c- surgical blade installation)

Study outcomes

There were two main outcomes of the current study; the primary outcome was the Little's irregularity index (LII) and its percentage of change, and the secondary outcome was the time taken to finish the leveling and alignment stage.

Measurements and observations

A. LII and percentage of change

The upper arch was directly digitally scanned using Medit i500 IOS before treatment (T0) and every first 6 weeks (T1-T2-T3-T4-T5-T6) and then every month until the 5th month of treatment (T7-T8-T9-T10); digital models were fabricated before, during, and after treatment using the scanner's software.[27,28]

Using computer software (the 3Shape Ortho System), the Little's Index of Irregularity (LII) was measured for the upper anterior teeth of digital models using a digital caliper tool before treatment (T0) and during treatment (T1–T10). LII measured the points precisely from the anatomic contact point of one tooth to the anatomic contact point of the adjacent tooth to obtain five horizontal linear measurements in millimeters for each arch. These horizontal linear measurements were made horizontally parallel to the occlusal plane as much as possible to represent only the horizontal displacement of the anatomic contact points for the anterior teeth[29,30] [Figure 5].

Then, ten linear measurements, five for each arch, were performed to estimate LII, which reflected the degree of anterior teeth malalignment improvement from T0 to T10; these ten measurements were then recorded. The leveling and alignment improvement percentage (LAIP) was calculated by subtracting the amount of change in the LII value at a specific time

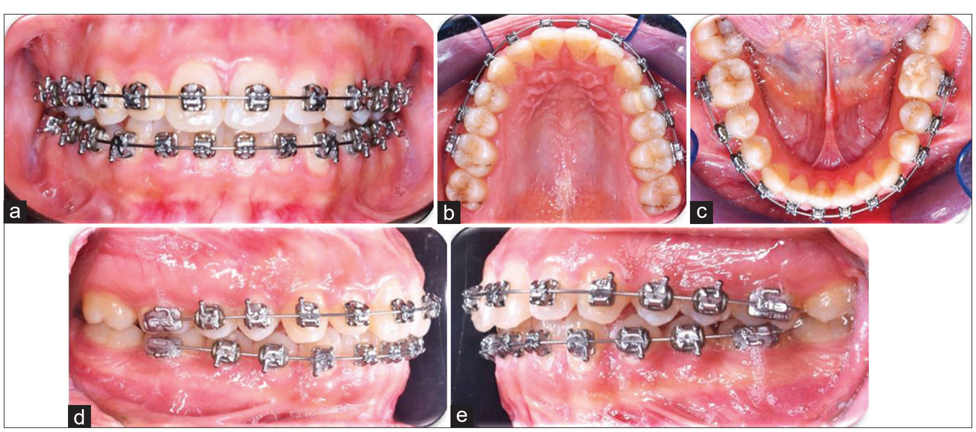


Figure 4: Progressive intraoral photographs for a sample of the experimental group (a- frontal, b- upper, c-lower, d- left lateral, e- right lateral intraoral photographs)

point (T1, T2, T7, etc.) from the LII value just before initial wire placement (T0). The value obtained was then divided by the value of LII at T0 and multiplied by 100. These calculations are represented in the following equation:

$$LAIP = T(0) - T(X) = Y/T(0) \times 100,$$

where LAIP is the leveling and alignment improvement percentage, T(0) is the LII value just before initial wire placement, T(X) is the LII value at a specific time point (T1, T2, T7, etc.), and Y is the value obtained from subtracting T(0) from (TX).

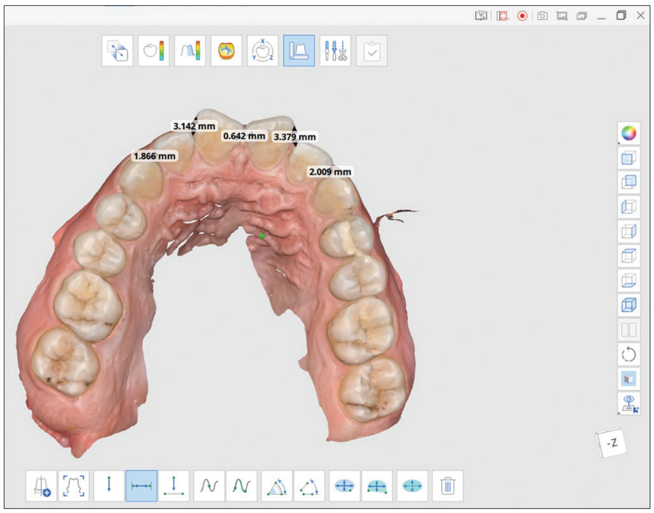


Figure 5: Digital caliper tool used to measure LII on a digital model using 3Shape Ortho System software

B. The time taken for finishing the leveling and alignment stage

The time taken can be calculated by the number of weeks taken for finishing the leveling and alignment stage for both the experimental and control groups.

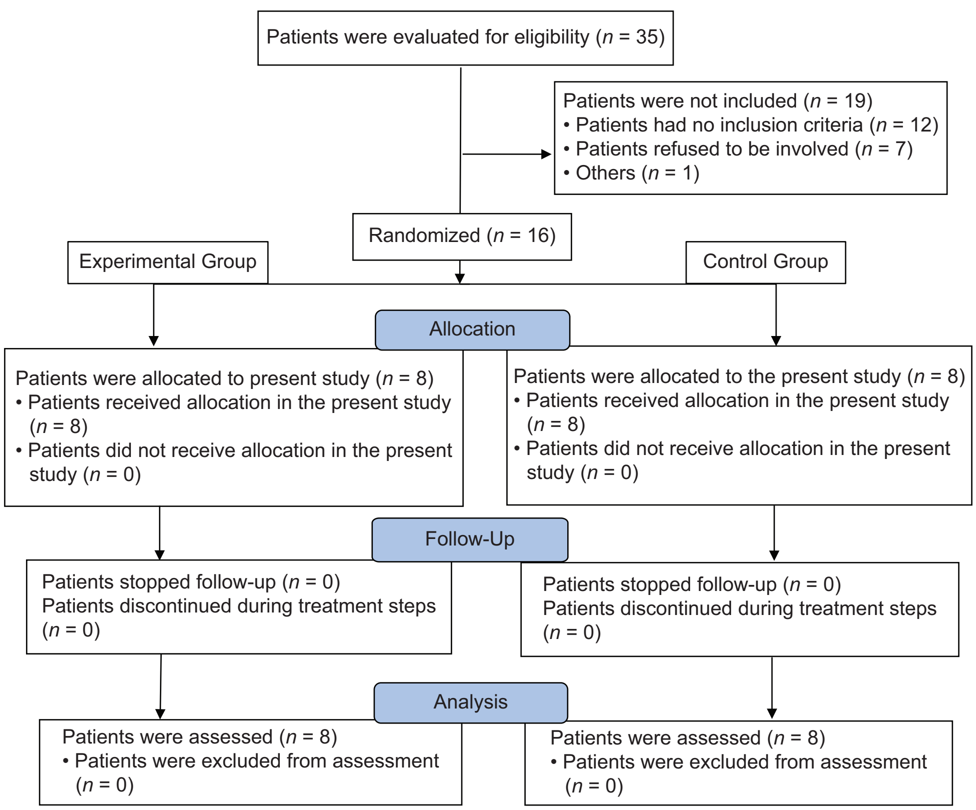
Data management and statistical analysis

The data were collected, tabulated, and statistically analyzed using Statistical Package for Social Sciences (SPSS program, version 18, Inc., Chicago, IL, USA).

Results

All 16 patients who participated in the present study had a complete analysis for the percentage of change in LII and at all time intervals (T0 to T10) without any dropouts [see participant flow diagram]. Each participant had follow-ups each 3 weeks at the orthodontic clinic.

Data were explored for normality using the Kolmogorov–Smirnov test of normality. All measurements were nonparametric, so Mann–Whitney tests were used for



Participants' flow diagram

intergroup comparison, whereas the Freidman Test and Wilcoxon signed-rank test were used for intragroup comparisons.

Little's Index of irregularity and percentage of change

The amount of OTM is not equal in all patients at both groups and it is variable among study participants, so mean values can be calculated at each time interval as amount of LII.

Based on a comparison of values of LII for the upper arch within the same group, both groups reported a gradual statistically significant decrease throughout the study. The difference between different time points was statistically significant ($P < 0.001$). A post hoc test revealed no significant difference between T9 and T10 [Table 1].

Conversely, a comparison of values of LII for the upper arch between the two groups showed no significant difference between groups at different time intervals [Table 2].

Based on a comparison of the percentage of change in LII for the upper arch between the two groups, the experimental group recorded values that were significantly greater than those recorded in the control group at all time intervals T0–T7 but not T8–T10. Both groups recorded (100 ± 0%), with no significant difference between groups ($P = 1$; Table 3).

The time taken for finishing the leveling and alignment stage

The experimental group recorded 11 ± 2.83 weeks, whereas the control group recorded 13.5 ± 2.07 weeks, with no significant difference between groups ($P = 0.063$; Figure 6).

Table 1: Descriptive statistics and comparison of LII at different time points within the same group (repeated measures ANOVA test and paired *t*-test)

Groups	Experimental group			Control group		
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
T0	8.97[a]	2.22	9.60	7.80[a]	2.97	7.11
T1	7.12[b]	1.67	7.74	7.17[b]	2.70	6.46
T2	5.61[c]	1.37	5.78	6.49[c]	2.53	6.14
T3	4.43[d]	1.37	4.53	5.75[d]	2.30	5.77
T4	3.48[e]	1.22	3.62	4.99[e]	2.25	5.22
T5	2.58[f]	1.45	3.02	4.18[f]	2.22	4.30
T6	1.84[g]	1.31	2.38	3.46[g]	2.19	2.80
T7	1.40[h]	1.08	1.79	2.95[h]	2.21	2.09
T8	0.98[i]	0.81	1.46	2.46[i]	2.21	1.23
T9	0.03[j]	0.08	0.00	0.49[j]	0.82	0.00
T10	0.00[j]	0.00	0.00	0.00[j]	0.00	0.00
P value within the same group		0.000*			0.000*	

Significance level $P \leq 0.05$, *significant. *Post hoc* test, within the same column, values sharing the same superscript letter are not significantly different

Discussion

To properly finish the study, patient cooperation was required, and the patients received strict instructions to follow through on their follow-up appointments and to be totally dedicated to them. So, fortunately, all patients enrolled in the study proceeded until completion, and no one dropped out, so the statistical analyses were performed on the total pre-calculated sample size.

The age of the patients who participated in the study ranged from 12.4 to 17.6 years, and the mean age was 14.98 years; this age group was the most abundant in the outpatient clinic. Also, selecting this age range allowed the complications associated with adult orthodontics to be avoided. This narrow range of ages also minimized the individual differences that might have arisen as a result of large age variations.

Similar studies have used LII measured directly on a gypsum cast derived from a conventional impression or on a digital scan of a gypsum cast. However, the present study is the first to utilize LII for measurements on a digital impression from a direct intraoral scan for more accuracy and precision.[26–28]

An intraoral scanner was used to take digital impressions from the patients participating in the study. When compared to measurements from conventional impressions, virtual models created from intraoral scanning seemed to be more accurate and reliable. Also, this method eliminates the need for impression materials, takes less time and requires fewer steps, and is convenient for patients.[27]

Although previous studies were quite similar to the present study regarding the participants' selection

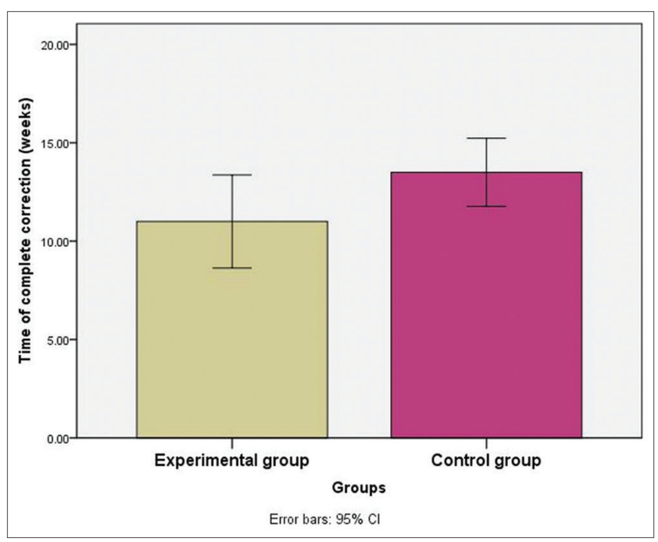


Figure 6: Bar chart for the mean value of time taken for leveling and alignment for both groups (by weeks)

Table 2: Descriptive statistics and comparison of LII between groups (independent *t*-test)

Time	Groups	Mean	Std. Dev.	Median	Difference				*t*	*P*
					Mean	Std. Dev.	C.I. lower	C.I. upper		
T0	Experimental group	8.97	2.22	9.60	1.16	1.31	-1.65	3.97	0.888	0.390 ns
	Control group	7.80	2.97	7.11						
T1	Experimental group	7.12	1.67	7.74	-0.05	1.12	-2.46	2.36	-0.047	0.963 ns
	Control group	7.17	2.70	6.46						
T2	Experimental group	5.61	1.37	5.78	-0.88	1.02	-3.07	1.30	-0.868	0.400 ns
	Control group	6.49	2.53	6.14						
T3	Experimental group	4.43	1.37	4.53	-1.33	0.95	-3.36	0.70	-1.402	0.183 ns
	Control group	5.75	2.30	5.77						
T4	Experimental group	3.48	1.22	3.62	-1.51	0.90	-3.45	0.43	-1.673	0.117 ns
	Control group	4.99	2.25	5.22						
T5	Experimental group	2.58	1.45	3.02	-1.60	0.94	-3.61	0.41	-1.706	0.110 ns
	Control group	4.18	2.22	4.30						
T6	Experimental group	1.84	1.31	2.38	-1.62	0.90	-3.55	0.32	-1.789	0.095 ns
	Control group	3.46	2.19	2.80						
T7	Experimental group	1.40	1.08	1.79	-1.55	0.87	-3.42	0.32	-1.781	0.097 ns
	Control group	2.95	2.21	2.09						
T8	Experimental group	0.98	0.81	1.46	-1.48	0.83	-3.37	0.41	-1.777	0.110 ns
	Control group	2.46	2.21	1.23						
T9	Experimental group	0.03	0.08	0.00	-0.46	0.29	-1.15	0.22	-1.599	0.153 ns
	Control group	0.49	0.82	0.00						
T10	Experimental group	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1 ns
	Control group	0.00	0.00	0.00						

C.I. 95% confidence interval, $P \leq 0.05$, *significant, ns=nonsignificant. The time intervals between scans up to T8 is 1 week. The time interval between T8 and T9 is 4 weeks. The time interval between T9 and T10 is 4 weeks

Table 3: Descriptive statistics and comparison of the percentage of change from baseline in LII between groups (Mann–Whitney *U*-test)

Time	Groups	Mean	Std. Dev.	Median	Difference				*P*
					Mean	Std. Dev.	C.I. lower	C.I. upper	
T1	Experimental	19.97	10.01	24.77	11.86	3.65	3.42	20.30	0.012*
	Control	8.11	2.57	7.53					
T2	Experimental	36.65	12.21	38.95	19.25	5.30	7.88	30.62	0.003*
	Control	17.40	8.70	13.11					
T3	Experimental	50.39	13.00	47.42	23.36	6.28	9.88	36.84	0.002*
	Control	27.03	12.12	22.88					
T4	Experimental	60.50	12.62	59.69	23.45	7.09	8.25	38.65	0.005*
	Control	37.04	15.58	29.31					
T5	Experimental	70.19	16.17	66.18	21.94	8.34	4.06	39.81	0.020*
	Control	48.26	17.15	41.63					
T6	Experimental	78.72	15.64	75.00	20.35	8.76	1.57	39.13	0.036*
	Control	58.37	19.20	53.84					
T7	Experimental	83.92	12.48	81.23	18.48	8.38	0.50	36.45	0.045*
	Control	65.44	20.16	67.29					
T8	Experimental	88.73	9.88	84.77	16.56	7.95	-1.11	34.24	0.063ns
	Control	72.17	20.20	78.70					
T9	Experimental	99.70	0.84	100.00	5.08	3.41	-2.96	13.11	0.179ns
	Control	94.63	9.60	100.00					
T10	Experimental	100.00	0.000	100.00	0.000	0.000	0.000	0.000	1 ns
	Control	100.00	0.000	100.00					

C.I. 95% confidence interval, $P \leq 0.05$, *significant, ns=nonsignificant

criteria, there were differences in terms of the nature of the surgical technique and time intervals in which measurements were obtained. The time intervals in the present study were the shortest (on a weekly basis) because mild crowding could be corrected within 4 to 6 weeks; hence, the weekly-timed intervals were suggested to accurately measure the rate of OTM.[26,28]

In the present study, corticision was performed using reinforced 15T scalpel blades. The scalpel was positioned at an angle of 45°:60° to the tooth's longitudinal axis on the attached gingiva between the roots of the teeth. The angulation of the scalpel during the procedure was intended to incorporate as much bony surface area as possible to be cut. The scalpel blade was progressively inserted into the gingiva, cortical bone, cancellous bone, and bone marrow by tapping the scalpel handle with a surgical mallet.[22]

To avoid losing alveolar crest bone, care was taken to leave roughly 5 millimeters of papillary gingiva. About two-thirds of the length of the root was penetrated by the scalpel, with a depth of 1 centimeter. The scalpel was extracted with a cautious swinging motion. Six locations were used for the surgical procedure (distal to each maxillary anterior teeth).[22]

Corticision was performed once just before the insertion of the first arch wire. Multiple corticisions were avoided to minimize patient discomfort and side effects.

A comparison of different time intervals values within the same group showed both groups recorded a steady statistically significant decline in LII values in the maxillary dental arch. At each time point, there was a statistically significant difference ($P = 0.000$). Time points T9 and T10 did not significantly vary, according to the *post hoc* test. This can be attributed to the gradual correction of the arch length and tooth material discrepancy throughout the period of the study. There was no remarkable variation in the LII values between the last two time points (T9 and T10) because almost all the crowding was resolved by the end of the period of study.

Based on a comparison of the percentage of change in LII for both arches between the two groups, the experimental group recorded values that were significantly greater than those recorded in the control group at all time intervals (T0–T7); this result can be attributed to the use of two methods for accelerating orthodontic tooth movement in the experimental group: corticision and the self-ligating bracket system. However, in T8–T10, both groups recorded 100 ± 0%, with no significant difference between groups ($P = 1$) because almost all samples of both groups had finished the leveling and alignment stage at T8 (3.5 months).

Self-ligating brackets were the system of choice in the present study because they provide a mechanical aid for acceleration of OTM. A similar previous study used self-ligating bracket systems and concluded the group utilizing this type of bracket had a reduced treatment duration by up to 25%.[24]

Corticision has been claimed to be associated with the regional acceleratory phenomenon (RAP). The term RAP refers to a process in which tissue forms more quickly than the typical regional regeneration process in a localized response to irritating stimuli. Research has indicated orthodontic forces cause inflammatory markers, including chemokines and cytokines, to become more active. It is hypothesized surgical bone irritation boosts these factors' expression, which should quicken tooth movement. Park *et al*.'s histological investigation demonstrated limited alveolar decortication accelerated alveolar spongiosa turnover.[22]

As for the time taken to finish the leveling and alignment stage, the experimental group recorded 11 ± 2.83 weeks, whereas the control group recorded 13.5 ± 2.07 weeks with no significant difference between groups ($P = 0.063$). The explanation is that the experimental group (doubly qualified by the combination of two methods for the acceleration of OTM) finished the leveling and alignment stage before the control group but without any statistical significant difference because of the presence of only a small amount of crowding.

Conclusion

- The self-ligating bracket system combined with corticision accelerates the rate of orthodontic tooth movement more than in case of using a self-ligating bracket system only.
- The greater effect of corticision was applied in early time of the leveling and alignment stage.
- The self-ligating bracket system combined with corticision correct the mild to moderate anterior teeth crowding of the Class I orthodontic patients in a time shorter than in the case of using a self-ligating bracket system only.

Ethical statement

The current study was approved by the Ethics Committee for Dental Research, Faculty of Dental Medicine of the same institution of corresponding author with number 721/271. The present study was also submitted to ClinicalTrials.gov.

Patient consent

The objectives of the study were discussed with the patients, parents, or guardians, and an informed consent form and the orthodontic instructions sheet were signed before the start of orthodontic treatment.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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