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THE EFFECT OF CORTICOTOMY ON ORTHODONTIC TOOTH MOVEMENT ACCELERATION DURING EN-MASSE RETRACTION IN ADULT PATIENTS: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

Aim of the study: The objective of this study was to assess how corticotomy-assisted orthodontics affects the rate of miniscrew supported en-masse retraction of maxillary anterior teeth.

Materials and methods: The sample of this study comprised 20 female adult patients with age ranging from 18-27 years, in need of fixed orthodontic mechanotherapy which included extraction of maxillary first premolars and anterior en-masse retraction. The sample was divided into 2 groups: Group 1: extraction with corticotomy and Group 2 : extraction without corticotomy (Control). Both groups were evaluated regarding rate of maxillary anterior teeth retraction and the amount of maxillary first permanent molar movement.

Results: Group 1 had higher en-masse retraction rate than Group 2. In the 1st, 2nd , 3rd , 4th and 5th month, Group 1 also showed higher mean anterior retraction rate than Group 2 that was statistically significant. In Group 1, the highest retraction rate was found in the 1st month, followed by the 2nd, 3rd, 4th month then 5th month with statistical significance in-between each. However in Control group, the difference between retraction rates at different times was not statistically significant. Slight distal molar movement occurred in both groups but was not statistically significant

Conclusion: Corticotomy accelerates orthodontic tooth movement with increased rate of en-masse retraction compared to conventional orthodontics without corticotomy. Mild distal molar movement occurred in both groups and was slightly higher in Corticotomy group but was not statistically significant.

KEYWORDS: Corticotomy, Corticotomy-assisted orthodontics, Regional acceleratory phenomenon

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INTRODUCTION

The ultimate purpose of orthodontic treatment is to achieve best esthetic outcome in the shortest possible duration of time. [1,2] Extraction of premolars and space closure, whether two-step or en-masse retraction is the most common treatment plan to relieve crowding and/or bimaxillary protrusion.[3] In such cases, treatment duration could exceed two years or even more in certain cases. [4-6] Using conventional orthodontic procedures, tooth movement can be accomplished but with a limited rate.[7]

Acceleration of orthodontic tooth movement has been implemented through various techniques such as corticotomy assisted orthodontic treatment (CAOT) developed in 1996 specifically for adult patients.[8,9] Corticotomy is defined as an intentional injury done to cortical bone. Also known as regional acceleratory phenomena (RAP), orthodontic tooth movement is accelerated due to the increase of bone remodelling as the number of osteoblasts and osteoclasts are increased and the resistance of dense cortical bone to orthodontic tooth movement is eliminated.[10-15] Therefore, a 2-3 year orthodontic treatment is reduced to the one that takes 3-6 months with minimum risk of external root resorption, patient compliance and periodontal problems. [16,17] It involves the application of well-planned force systems to bone with minimal resistance against tooth movement.[16] However, it has been reported that this technique is a rather invasive procedure.[8] Less invasive technique, named "flapless corticotomy", has been introduced in which a piezoelectric knife was utilized for alveolar bone decortication through gingival incisions performed vertically and interdentally.[18] However, the results documenting the effectiveness of this technique have been contradictory.[19]

In addition to increasing the speed of orthodontic tooth movement, additional advantages for corticotomy include reduced pain and root resorption, improved stability and minimal relapse, good periodontal condition and no evidence of loss of tooth vitality.[17] Besides anterior teeth retraction, corticotomies can also be used for other treatments such as canine retraction[20], rapid maxillary expansion, molar uprighting[21], decrowding.[22] and scissor bite correction.[23]

There have been controversies regarding the ideal way to preserve and achieve maximum anchorage in extraction cases.[6,24] Although it would result in double the treatment time, two-step retraction has been recommended since the reaction force would be distributed over the large posterior anchorage unit[25,26] Others questioned the reliability of this technique and advocated for en-masse retraction as Staggers and Germane[27], who suggested that anchorage was being strained twice with a two-step retraction as opposed to one with en-masse retraction. Also, two-step retraction results in rotation and mesiodistal tipping of the canine.[28] Recent techniques have been introduced such as titanium orthodontic miniscrews which provide absolute anchorage without the need for patient compliance with extraoral appliances and achieve better treatment quality and shortened treatment duration.[29-32]

The aim of this research was to assess the effect of corticotomy on the rate of orthodontic tooth movement during anterior space closure by en-masse retraction as well as anchorage loss.

MATERIALS AND METHODS

Ethics committee approval

This prospective study was approved by the Research Ethics Committee of the Faculty of Dentistry, Cairo University. The details of the procedure and surgical intervention were clarified to the patients and a consent form was signed by all the patients before attempting treatment.

The sample of this study included 20 adult female patients selected from the outpatient clinic of the Department of Orthodontics, Faculty of

Dentistry, Cairo University. Their age range was (18-27 years) .The inclusion criteria were: (1) Full permanent dentition excluding third molars; (2) Class II division 1 malocclusion with no or mild crowding, with maxillary or bimaxillary protrusion necessitating extraction of maxillary first premolars and anterior teeth retraction; (3) skeletal mild to moderate class II malocclusion; (4) normal or increased lower anterior facial height; (5) Increased overjet in maxillary protrusion 5-10 mm; (6) no previous orthodontic treatment; (7) absence of systemic diseases and craniofacial syndromes; (8) good oral hygiene and periodontal health; (9) no consumption of medication which could affect bone biology or tooth movement; (10) good bone morphology.

The sample was divided randomly into two equal groups: Group 1 constituted 10 subjects and were assigned to the corticotomy assisted group (CAG) whereby maxillary anterior teeth retraction was preceded by surgical corticotomy and 10 patients were assigned to Group 2 (Control group) (CG) whereby maxillary anterior teeth retraction was performed without corticotomy using conventional technique. Both groups had miniscrews placed in the maxillary arch for anchorage reinforcement.

Full orthodontic diagnostic records including digital panoramic and lateral cephalometric radiographs, intraoral and extraoral photographs as well as study models were obtained for all the patients before the beginning of treatment (T0) and following space closure (T5). Lateral cephalometric tracing as well as model analysis were done for all patients. Conventional fixed orthodontic brackets were bonded (MBT prescription, 3M Unitek, California, USA), slot size 0.022 x 0.028-inch. Following alignment and leveling, self-drilling miniscrews made of titanium (3M Unitek, Monrovia, California, diameter 1.3 mm; length 8 mm) for anchorage reinforcement were placed between the roots of maxillary second premolars and first molars on the right and left sides 8-10 mm above the archwires. The miniscrews were tied to these teeth using 0.010-inch ligature wire. Throughout treatment, the screws were re-checked every visit for stability and replaced if necessary. None of the miniscrews showed any signs of loosening or failure. Leveling and alignment began with 0.014 inch nickel titanium archwire (NiTi), then followed by this sequence: 0.016 inch NiTi , 0.016 x 0.022 inch NiTi,, 0.017 x 0.025 inch NiTi, 0.019×0.025 inch NiTi, until rectangular 0.019 x 0.025 inch stainless steel (SS) was reached. Then, crimpable hooks 7 mm long were placed distal to the maxillary lateral incisors (Ortho technology, South Carolina, USA). Patients were instructed to maintain good oral hygiene measures throughout the treatment using toothbrush and fluoridated toothpaste three times a day as well as interdental brush and chlorohexidine mouthwash (0.12%) twice daily.

Surgical procedure

Group 2 patients (Control Group) were referred to the Oral & Maxillofacial Surgery Department at Faculty of Dentistry, Cairo University for extraction of the upper first premolars while Group 1 patients (Corticotomy group) were referred to the same department to perform extraction and corticotomy procedure. All surgical procedures were performed by the same oral and maxillofacial surgeon.

Under local infiltration anesthesia (ARTINIBSA 40 mg/0.01 mg/ml, Inibsa Dental S.L.U, Barcelona, Spain) a full thickness mucoperiosteal flap was elevated labially and palatally around all the maxillary anterior teeth extending from the distal surface of the maxillary right 1st premolar to the distal surface of the maxillary left 1st premolar. Then vertical cuts, 3 mm in depth, were made between the upper anterior teeth roots using a piezotome device under copious irrigation (Piezotome SOLO; Satelec Acteon, Bordeaux, France).The cuts were carried out 2-3 mm apical to the alveolar crest. Then they were extended 3 mm above the root apices (Figure 1). Only cortical surface scoring and not through and through penetration was performed. Then subapical horizontal corticotomy cuts were

done to connect the vertical cuts. Cortical bone perfortations were also performed in between the vertical cuts. Upper first premolars extraction was carried out for all patients at the same time of corticotomy. Additional vertical cut in the extraction sockets was performed in the socket walls distal to the canine teeth. Similarly, a flap was raised on the palatal side for decortication of the palatal bone connected by subapical horizontal cuts for RAP to occur (Figure 2). Bone graft was mixed with saline and placed over areas that underwent corticotomies (Bioteck S.p.A., Via E. Fermi 49, Italy) (Figure 3). Repositioning and suturing of the raised flap back into place was carried out using 4-0 vicryl sutures (Assut Assucryl PGA, Switzerland) using the interrupted suturing technique. Following the corticotomy procedure, all patients were instructed to take antibiotic Augmentin, 1000 mg, one tablet twice daily for one week, paracetamol (500 mg orally) for pain alleviation whenever needed, cold packs for 6-8 hours after the surgery, maintain adequate oral hygiene and eat only soft food for five days after the surgery. The day after surgery, the patients began to use chlorhexidine mouthwash (15 ml of 0.2% chlorhexidine solution) twice a day for 5 days.

Fig. (1) Showing labial corticotomy vertical interdental cuts connected by subapical horizontal cuts

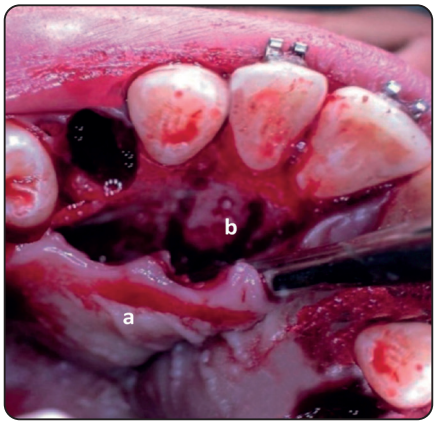

Fig. (2) Showing palatal flap elevation (a) with vertical interdental cuts (b) connected by subapical horizontal cuts

Orthodontic procedure

En-masse retraction of the six maxillary anterior teeth was started in both groups of patients 5 days following corticotomy in Group 1 and 5 days following extraction in Group 2. Retraction was done on 0.019 x 0.025-inch SS archwires. Nickel-titanium closed coil springs, 9 mm in length (American Orthodontics, Wisconsin, USA) were attached from the crimpable hooks bilaterally onto the posterior miniscrews (Figure 4). A force of 250 grams per side was applied and measured utilizing a force calliper (Dentaurum, Ispringen, Germany). The patients were scheduled for follow up every two weeks for re-activation of the NiTi coil springs in Group 1 and every 3 weeks in Group 2 .

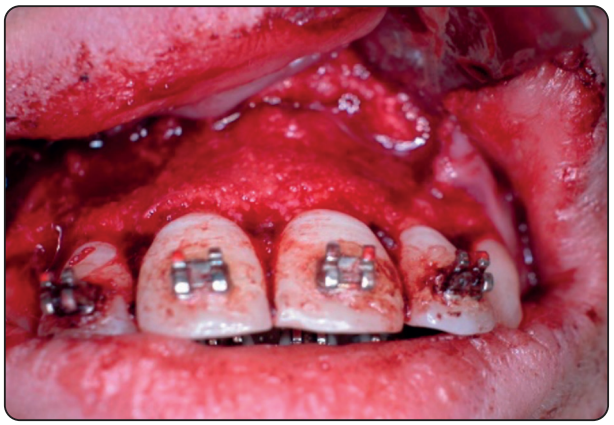

Fig. (3) Showing the placement of Bone Graft material in the area that underwent corticotomy

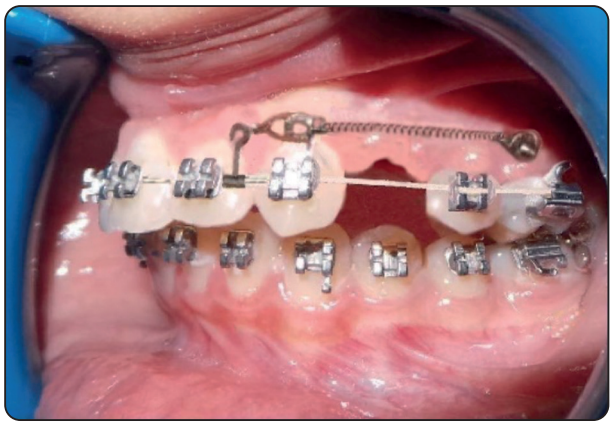

Fig. (4) Showing En-masse maxillary anterior retraction utilizing NiTi coil springs on orthodontic miniscrews

To record the retraction rates of maxillary anterior teeth as well as anteroposterior upper first permanent molar movement, alginate impressions were taken for the patients after finishing the alignment and leveling phase before beginning en-masse retraction (T0), then after 1 month (T1), 2 months (T2), 3 months (T3) 4 months (T4) and 5 months (T5). Before taking the impressions, the archwires were removed and elastic ligatures were applied around the brackets to prevent the alginate impressions from being distorted. The alginate impressions were poured into stone casts.

The stone models were used for measuring the amount of upper anterior teeth retraction as well bilaterally every month according to Ziegler and Ingervall [33] (Figure 5).The stone models were digitally photographed using a digital camera (Canon EOS 5D Mark III, Tokyo, Japan). A millimetric ruler was located beneath the stone model for image calibration. Landmarks were identified and the measurements were obtained from the digital images by an image analysis software (Image J; NIH, Bethesda, MD) as advised by Al-Imam et al [34] (Figure 6). The monthly en-masse retraction rate was calculated through measurement of the distance from the maxillary anterior teeth to the medial endpoint of the 3rd palatine rugae (distance to a line perpendicular to the mid-palatal suture). The means of both sides were used to calculate the amount of anterior teeth retraction. The amount of anteroposterior molar movement was calculated for the right and left sides individually by measuring vto the medial endpoint of the 3rd palatine rugae for the 5 months duration of the study. Maxillary en-masse retraction lasted until canines reached Class I relation. Pre- and post-treatment photographs for a Group 1 patient in shown is Figures (7 & 8).

To assess reliability and rule out any methodological errors, one of the authors did the measurements twice (D.O.) after two weeks and then they were repeated by the other co-author (S.E.) at different time points.

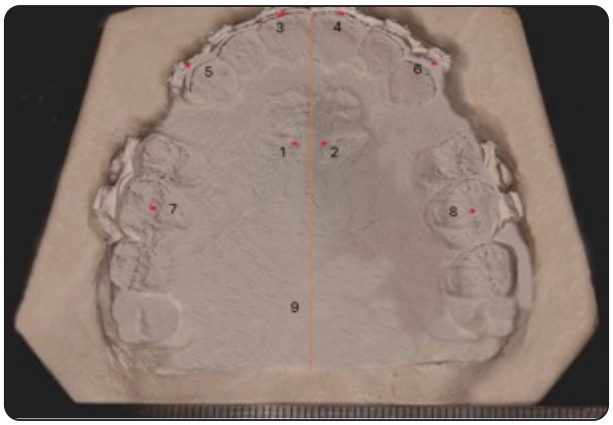

Fig. (5) Showing Landmarks on the study model (1) Medial point of right 3rd palatine rugae. (2) Medial point of left 3rd palatine rugae. (3): Maxillary right incisor edge midpoint. (4) Maxillary left incisor edge midpoint. (5) Maxillary right canine cusp tip (6) Maxillary left canine cusp tip. (7) Central fossa of maxillary right first molar. (8) Central fossa of maxillary left first molar. (9) Middle palatine suture

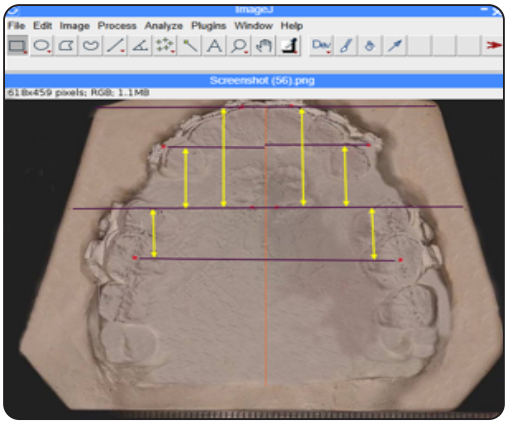

Fig. (6) Image J software for measurements on the digitized photographs

Fig. (7): Showing pre-treatment extraoral and intraoral photographs for Group 1 patient

Fig. (8): Showing post-treatment extraoral and intraoral photographs for a Group 1 patient

Sample Size Calculation

A power analysis was developed to own sufficient power for the application of a two-sided statistical test of the null hypothesis that there would be no difference between tested groups regarding anterior retraction rate. By adopting alpha (α) and beta (β) levels of (0.05) (i.e. power=95%) and an effect size (d) of (2.03) calculated according to the results of a previous study[35] the total required sample size (n) was found to be (16) subjects. Sample size was increased by (25%) to compensate for possible dropouts during different follow up intervals to (20) subjects (i.e., 10 subjects per group). Sample size calculation was done using R statistical analysis software version 4.3.2 for Windows*.

STATISTICAL ANALYSIS

Numerical data were inspected for normality by checking the distribution of data as well as utilizing normality tests (Kolmogorov-Smirnov and Shapiro-Wilk tests. Data were presented in the form of mean and standard deviation (SD) values. Data showed parametric distribution. Repeated measures Analysis of Variance (ANOVA) was utilized to compare the values between the groups in addition to within each group. Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. Student's t-test was used to compare between total amount of anterior retraction in the two groups as well as amount of molar movement per each side. The significance level was set at $P \leq 0.05$. Interobserver and intraobserver reliability were evaluated using interclass correlation coefficients (ICCs). The confidence level was set at 95%.

Statistical analysis was carried out with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

* R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RESULTS

Baseline characteristics

Descriptive statistics for baseline characteristics of the two study groups are presented in Table (1). All participants were females. The mean & standard deviation (SD) values for age were 22.8 (±3.3) and 23.5 (±2.9) years old in Corticotomy and Control groups, respectively. Minor crowding was observed in 40% and 50% of the cases in the two groups, respectively. Regarding protrusion of maxillary anterior teeth in Corticotomy group, 50% of participants had moderate and 50% had severe protrusion while in Conventional group, 70% of participants had moderate and 30% had severe protrusion. Hyperdivergent facial pattern was observed in 70% of participants in Corticotomy group compared to 40% of participants in Control group. Shallow overbite was observed in 80% and 60% of participants in the two groups, respectively.

TABLE (1) Frequencies (n), percentages (%), mean and standard deviation (SD) values for baseline characteristics in Group (1) Corticotomy group and Group (2) Control group

Base line characteristics	(Corticotomy) (n = 10)	Control (n = 10)
Gender [n, (%)]		
Female	10 (100%)	10 (100%)
Age [Mean, (SD)]	22.8 (3.3)	23.5 (2.9)
Crowding [n, (%)]		
None	6 (60%)	5 (50%)
Minor	4 (40%)	5 (50%)
Protrusion of maxillary anterior teeth [n, (%)]		
Moderate	5 (50%)	7 (70%)
Severe	5 (50%)	3 (30%)
Facial pattern [n, (%)]		
Normal	3 (30%)	6 (60%)
Hyperdivergent	7 (70%)	4 (40%)
Overbite [n, (%)]		
Normal	2 (20%)	4 (40%)
Shallow	8 (80%)	6 (60%)

Maxillary anterior teeth retraction rate per month (mm/month)

The mean anterior retraction rates for both groups are displayed in Table (2) (Figure 9). Retraction rates were expressed as the distance anterior teeth covered per month. Measurements performed at the assigned time points : the 1st , 2nd , 3rd , 4th and the 5th month revealed that Group 1 (Corticotomy group) had higher mean upper anterior en-masse retraction rates compared to Group 2 (Control group) which was statistically significant (*P*-value <0.001, Effect size = 0.94), (*P*-value <0.001, Effect size = 0.916), (*P*-value <0.001, Effect size = 0.89) and (*P*-value <0.001, Effect size = 0.903) and (P-value <0.001, Effect size 0.86) respectively.

TABLE (2) The mean, standard deviation (SD) values, results of repeated measures ANOVA test for comparison between anterior en-masse retraction rates (mm/month) in Groups 1 & 2 and comparison between retraction rates within each group .Student's t-test for comparing between total retraction rate between the two groups

Time	Corticotomy (n = 10)		Control (n = 10)		P-value	Effect size (Partial eta squared)
	Mean	SD	Mean	SD		
T 1	1.81 A	0.19	0.64	0.12	<0.001*	0.94
T 2	1.68 B	0.18	0.75	0.12	<0.001*	0.916
T 3	1.52 C	0.19	0.71	0.09	<0.001*	0.89
T 4	1.3 D	0.12	0.67	0.1	<0.001*	0.903
T 5	0.91 E	0.12	0.41	0.04	<0.001*	0.86
Total	7.22	0.52	3.18	0.23	<0.001*	*d* = 8.865
P-value	<0.001*		0.066			
Effect size *(Partial eta squared)*	0.834		0.354			

**: Significant at P ≤ 0.05, the different letters in superscripts within the same column denote statistically significant difference between the time points*

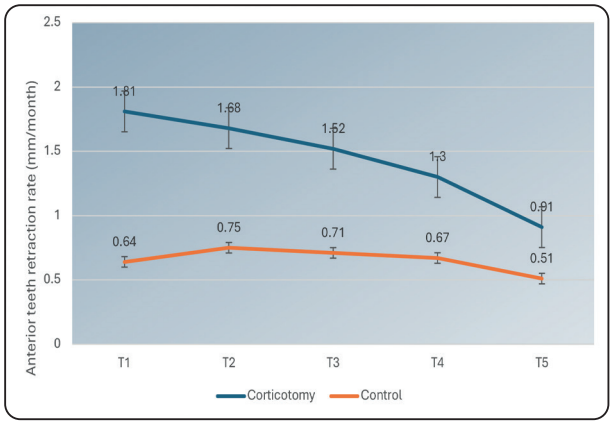

Fig. (9) Line chart displaying the mean and standard deviation values of maxillary anterior retraction rates in the two groups

Regarding the total amount of retraction after 5 months (duration of the study), Group 1(Corticotomy group) showed statistically significantly higher mean upper anterior en-masse retraction value than the Group 2 (Control group) (*P*-value <0.001, Effect size = 8.865).

Regarding comparison between retraction rates at different time points within Group 1(Corticotomy group), there was a statistically significant difference between the different time points (*P*-value <0.001, Effect size = 0.834). Pair-wise comparisons between times revealed that the statistically significantly

highest retraction rate was found in the 1st month. Statistically significantly lower mean rate was observed in the second month followed by 3rd month. The statistically significantly lowest mean retraction rate was observed in the 5th month.

While in Control group, no statistically significant difference existed among retraction rates at different time points (P=0.066).

A line chart displaying the mean and standard deviation values for anterior retraction rates in the two groups is depicted in Figure (9).

Molar movement (mm)

The total amount of mean maxillary first permanent molar movement (T0-T5) for both groups is shown in Table (3) (Figure 10). Within each group, on both sides, no statistically significant difference existed between mean molar movements (*P*-value = 0.328, Effect size = 0.378) for Corticotomy group and (*P*-value = 0.491), Effect size = 0.718) for Control group, respectively.

Regarding mean total molar movement per side, Group 1 (Corticotomy group) showed more distal molar movement than Group 2 (control group) which was not statistically significant (*P*-value = 0.404, Effect size = 0.619 for the right side and (P-value=0.184, Effect size = 0.421 for the left side). There was a mean minor distal molar movement of 0.52 (± 0.2) mm on the right side in the Corticotomy group compared to 0.41 (±0.3) mm in the Control group whereas on the left side there was a mean distal movement of 0.48 mm (±0.1) in the Corticotomy group versus 0.36 mm (±0.2) for the Control group. None of the results were statistically significant.

TABLE (3) Descriptive statistics of the mean and standard deviations of the maxillary first permanent molar movement on both sides (in mm) in 5 months in Groups 1 and 2 as well as the P values of the significance tests.

	Upper right 1st molar		Upper left 1st molar		P-value
	Mean	SD	Mean	SD	
Corticotomy G.					
(T0-T5)	0.52	0.2	0.48	0.1	**0.328(NS)**
Control G.					
(T0-T5)	0.41	0.3	0.36	0.2	**0.491(NS)**
P-value	**0.404 (NS)**		**0.186 (NS)**		

Significant at P≤ 0.05 ***NS= Non-significant***

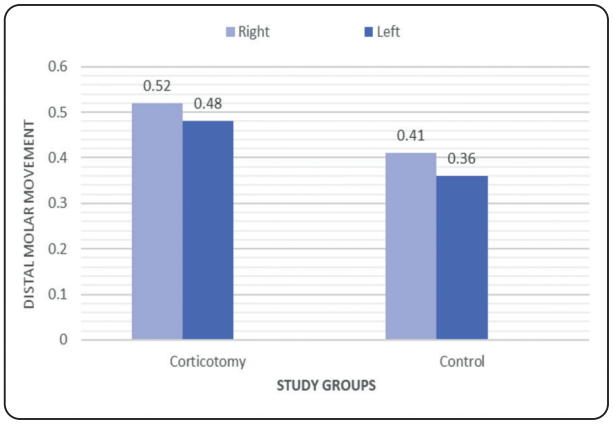

Fig. (10) Bar chart displaying mean values for molar movement in the two study groups (Corticotomy and Control)

All measurements (anterior teeth retraction and distal molar movement) were tested for intra- and interobserver agreement and it was found to be 0.99 (intraclass correlation coefficient).

DISCUSSION

The most important factors to consider during orthodontic treatment of dentoalveolar protrusion are achieving esthetics, proper function and stability. To reduce the unesthetic procumbency and lip incompetency associated with dental protrusion, the treatment plan usually involves extraction of first premolar teeth and retracting the incisors and canines utilizing maximum anchorage. The long duration of treatment associated with extraction cases has always been an obstacle to ideal orthodontic treatment.[36]

In the systematic review by Mavreas and Athanasiou[36] it was revealed that the duration of orthodontic treatment in premolar extraction cases may extend up to 18.6 months. Many authors have reported corticotomy to be a successful and a secure procedure for tooth movement acceleration "accelerated osteogenic orthodontics" [8,11,37-41] It mainly reduces cortical bone resistance to orthodontic force while keeping the marrow bone intact to maintain blood circulation, therefore minimizing the risk of necrosis. [42] Hence, this procedure was employed in our study to test its effectiveness in fastening orthodontic tooth movement.

The results of the current study declared that there has been a statistically significant higher en-masse retraction rate in the Corticotomy group compared to Control group per month throughout the 5 months duration of the study. This is similar to what has been disclosed by previous studies who reported that the tooth movement rate in en-masse retraction following corticotomy was twice as fast as that without corticotomy.[6,7,35] It is also in agreement with the results of Khlef and Hajeer [43] who recorded rates of tooth movement similar to our sample during the first four months in the traditional corticotomy group. The retraction rate in the Control group was within the average rate of conventional orthodontic retraction which ranged from 0.64 mm in the beginning of retraction to 0.51 mm at the end.

Likewise, a systematic review that was conducted in 2020[17] demonstrated that corticotomy-facilitated orthodontic tooth movement lessens the span of treatment by 2.2-3 folds in comparison to conventional orthodontic treatment. This has also been confirmed by other studies. [44-46] Results revealed that the peak of retraction rate is during the first two months which is correlated with the regional acceleratory phenomenon (RAP). [35,47] It was recommended to perform early appliance activation as well as shortening time intervals in between check-ups to 2 weeks for optimum results, not to lose the effectiveness of corticotomy [48-50] and for lengthening the period of the regional acceleratory phenomenon effect for more than 4 months.

In this study, we performed the traditional corticotomy technique with labial and palatal flap elevation to maximize the regional acceleratory phenomenon (RAP) necessary for tooth movement acceleration. Some studies advocated corticotomy only on the palatal or labial side to reduce duration of the operation and patient discomfort post-operatively. El Gemeay et al [51], administered a study to evaluate the duration of en-masse retraction combined with labial corticotomy and compare that with palatal corticotomy. Miniscrews for posterior anchorage reinforcement were used. There was significant maxillary incisor retraction in both groups without statistical significant difference between them (7.64 months in labial corticotomy group and 7.48 months in palatal corticotomy group). This was longer than the mean en-masse retraction time in our study which was completed in the 5th month following corticotomy which confirms a faster retraction rate with traditional corticotomy. Furthermore, we consider corticotomy on the labial side only insufficient for optimal acceleration of tooth movement. Although there is limited accessibility to the palatal side ,yet, it is important to decorticate the palatal cortical bone as well due to its increased thickness , which could be a hindering factor in orthodontic retraction. Since anterior retraction occurs in a palatal direction so

this corticotomy will reduce bone resistance to tooth movement. Our results are compatible with the results of Bhattacharya et al [7] who recorded a retraction duration of 4.35 months in the corticotomy group. Similarly, Chung et al[15] recorded that maxillary en-masse retraction was finished in 5 months duration.

In the present study, a piezotome was used to perform the corticotomy cuts instead of rotary instruments such as fissure and round burs as it allows precise incision of cortical bone without the risk of injuring adjacent soft tissues. Furthermore, cutting with a piezotome allows bone to heal without necrosis as less heat is generated during cutting with less blood which ensures a clean environment with a good vision. Additionally, patient acceptance is higher because of less noise and vibrations compared to conventional burs. [52] Our technique is similar to the one in the study by Vercelloti and Podesta [49] where they carried out conventional flap elevation and piezosurgery for accelerating tooth movement. Later on, Dibart et al[18] advocated a method of carrying out piezosurgery only with no elevation of flap and called this method "Piezocision". But its results have been controversial. Tuncer et al [19] revealed no effect of piezosurgical technique on the rate of orthodontic tooth movement during en-masse retraction. This is explained in the context of the different nature of the decortications used. In their study, they performed small vertical piezosurgical incisions on the labial side only while in our study decortications were done on both the labial and palatal sides and were also extended in a vertical and horizontal directions at the subapical level. This leads to reduction in the resistance of tooth movement. Moreover, no flap was reflected in their study. Flap reflection has a major role in triggering bone resorption due to loss of periosteal integrity. This results in a strong inflammatory response that accelerates tooth movement. [37,53-55] A systematic review by Figueiredo et al [56] concluded that the quality of evidence available is quite low to confirm that "Piezocision" or "flapless corticotomy" results in significant orthodontic tooth movement acceleration. In addition to the interdental cuts done with the piezotome in the current study, several small, round perforations were also made. This is a valid method for decortications and helps to promote healing stimulus. [57]

In the present study, premolars were extracted only a few days before starting en-masse retraction which is aligned with other studies.[37,53-55] Teeth extraction triggers inflammation and augments the decortications effect on the bone thus leads to tooth movement acclereration. This is in agreement with previous studies.[7,8,35] where concomitant premolar extraction and corticotomy were done. It is assumed that concomitant corticotomy and extraction can weaken the bone resistance to tooth movement and hasten the rate of en-masse retraction.

We placed bone graft in our study to increase the bone support for the teeth and overlying soft tissues.[57] This is also due to the fact that demineralization and remineralization of bone occurs ideally in a young age such as adolescents. However, in adult patients, bone remineralization might not occur sufficiently.[44] Therefore, bone grafting is recommended for provision of an alveolar housing during orthodontic tooth movement. [8,44,48,58]

Anchorage is quite critical in extraction cases. To reinforce anchorage, miniscrews were inserted bilaterally between the roots of the upper 2nd premolar and first permanent molar. This site was chosen because it is believed to be the ideal site for miniscrew insertion due to bone availability.[43,59] It is pertinent to avoid placement of the miniscrews in non-keratinized mucosa but in attached gingiva to increase their stability. Similar to our study, miniscrews have proven to be highly successful in reinforcing anchorage in en-masse retraction cases. [29.60] The miniscrews were used for both direct and indirect anchorage.[43] En-masse retraction was achieved using nickel-titanium closed coil springs as they apply light continuous force whereby elastomeric chains were not used due to

the degradation of the force that occurs with their usage.[61] To maintain physiological force levels, 250 grams of force were used per side during retraction of upper anterior teeth which is within physiologic limits and equally distributed on the upper anterior segment.[35] Hence this amount of force could move the teeth effectively without any adverse effects.[35,62] The teeth were stabilized with rectangular stainless steel archwire size (0.019" x 0.025) to achieve bodily or controlled tipping during anterior teeth retraction and minimize loss of torque. The waiting time before starting retraction was five days following corticotomy.[43] The follow up appointments for the patients in Group 1 were scheduled once every 2 weeks to take advantage of the regional acceleratory phenomenon (RAP).[20] The duration of the study was 5 months following corticotomy because it was stated to be the ideal time to gain the greatest effect of the regional acceleratory phenomenon that hastens the rate of tooth movement.[12] Furthermore, the undecorticated posterior segments would provide better anchorage control during treatment.[35]

In this study, the reference point used for measurement was the medial end of the 3rd palatine rugae as it is regarded as a stable landmark for measuring anteroposterior tooth movement. [20,63-66]

Regarding anteroposterior molar movement, there was a mild distal movement of the maxillary permanent first molars in the two study groups however, it was not statistically significant. Similar results were outlined by Upadhyay et al[60], Liu et al [67] and Khlef et al [68] who applied miniscrew anchorage for anterior retraction but without corticotomy. They deduced that this mild distalization was due to the transmission of retraction forces to the posterior segment through interdental contact between canines and second premolars after space closure. It could also be due to the forces of friction between the archwire, bracket slots and molar tubes during sliding mechanics in en-masse retraction. This finding depicts that space closure was achieved with pure en-masse retraction and not a combination of retraction and anchorage loss. That is why in our study, we used miniscrews for anchorage reinforcement to overcome any loss of anchorage that happens with conventional means such as headgear, second molars banding transpalatal arches where mesial molar movement has been reported with various degrees. [69,70]

CONCLUSIONS

-Maxillary en-masse retraction combined with corticotomy is a successful technique in increasing the rate of orthodontic tooth movement up to two folds.

-Corticotomy results in anchorage preservation during en-masse retraction on miniscrews with minor distalization of maxillary first molars but it was not statistically significant from the control group.

LIMITATIONS

A limitation of the present study is that patients recruited were only females. Another limitation is that it was conducted on the maxillary arch only. Future studies are recommended which include male as well as female patients and also assess the rate of en-masse retraction in the mandibular arch following corticotomy.

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