

Clinical and Biochemical Evaluation of Rate of Canine Retraction Following Piezocision through a Recently Extracted Site

Varthika Kumari¹, Waliullah Hamidi², Jacob T Kunnath³, Harnoor Dhillon⁴, Ravi M Subrahmanya⁵

ABSTRACT

Aim: In order to reduce orthodontic treatment time, numerous procedures such as systemic and local drug administration, mechanical and physical stimulation, and certain surgical procedures are being used. The aim of this study was to evaluate the clinical and biochemical effects of piezocision in a recently extracted site on the rate of canine retraction.

Materials and methods: Patients who required bilateral extraction of maxillary premolars were selected and piezocision was carried out on one side immediately after extraction followed by canine retraction using nearly 150 g of force. The rate of tooth movement was measured on dental study casts. Alkaline phosphatase and acid phosphatase levels in the gingival crevicular fluid (GCF) were used as indicators of bone turnover.

Results: The rate of tooth movement was higher on the piezocision side despite recent extractions on both sides. This was supported by concomitant changes in enzyme levels in the GCF.

Conclusion: The piezocision in recently extracted site increases the rate of tooth movement compared with that of the non-piezocision site. This increased rate of tooth movement was substantiated with the elevated enzyme levels indicating increased bone turnover with piezocision in a recent extraction site.

Clinical significance: Piezocision in a recently extracted site can be used as an aid to accelerate tooth movement, which would reduce the overall treatment duration. The procedure would be highly beneficial especially in adult patients seeking orthodontic treatment.

Keywords: Acid phosphatase, Alkaline phosphatase, Gingival crevicular fluid, Orthodontic space closure tooth movement, Piezocision.

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INTRODUCTION

An increasing number of adult patients seek orthodontic treatment today, in order to improve esthetics and/or masticatory function. Adult patients have mature bones with higher ratio of cortical bone and low bone turnover. The rate of orthodontic tooth movement is reduced due to these factors. The resulting increase in treatment duration can cause deleterious effects such as white spot lesions, dental caries, root resorption, and decreased patient compliance and satisfaction.

In order to reduce treatment time for such patients, numerous procedures that include systemic and local drug administration, mechanical and physical stimulation, and certain surgical procedures are being used. The surgical procedures utilize the regional acceleratory phenomenon (RAP) observed by Frost in 1983.¹ It is a tissue reaction to noxious stimuli, leading to an increased bone turnover rate by stimulation of osteoblasts and osteoclasts. Diedrich² and Häslér³ conducted studies that showed that tooth movement was faster and caused minimal damage to surrounding tissues.

Piezocision was introduced by Dibart⁴ as a minimally invasive technique to accelerate tooth movement. The procedure involves incisions in the buccal mucosa following local anesthesia. The incisions are made 2–3 mm below the base of the interproximal papilla. Following reflection of the gingiva and periosteum, the piezotome tip is inserted to a depth of 3 mm in order to decorticate the alveolar bone. The procedure can also be used to reflect a flap and place bone grafts, if needed, in a periodontally compromised patient.⁵

^{1–4}Department of Orthodontics and Dentofacial Orthopedics, NITTE (Deemed to be University), Mangaluru, Karnataka, India

⁵Department of Orthodontics and Dentofacial Orthopedics, AB Shetty Memorial Institute of Dental Sciences, NITTE (Deemed to be University), Mangaluru, Karnataka, India

Corresponding Author: Ravi M Subrahmanya, Department of Orthodontics and Dentofacial Orthopedics, AB Shetty Memorial Institute of Dental Sciences, NITTE (Deemed to be University), Mangaluru, Karnataka, India, Phone: +91 9845221386, e-mail: drmsravi@gmail.com

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Orthodontic tooth movement also brings about changes at a cellular level, which are evident in the form of changes in various enzyme levels in the gingival crevicular fluid (GCF).^{6,7} Alkaline phosphatase (ALP) and acid phosphatase (ACP) are the enzymes associated with bone metabolism as indicators of formative and resorptive activity, respectively.^{8,9} They are used as reliable indicators of the bone turnover rate at a specific site associated with tooth movement.

A search of literature revealed few studies that compared the rate of tooth movement into a fresh extraction site with and without

piezocision.¹⁰ The aim of this study was to compare the rate of canine retraction with and without piezocision. The findings were further supplemented by evaluation of GCF levels for ALP and ACP.

MATERIALS AND METHODS

The present study was carried out following clearance from the institutional scientific and ethical review boards at the AB Shetty Memorial Institute of Dental Sciences, Mangaluru. A total of 15 patients between the ages of 18 years and 26 years, indicated for bilateral extraction of first premolars for their orthodontic treatment, were included at random for this prospective study.

The included individuals had not undergone previous orthodontic treatment, had no systemic diseases (active/controlled) or craniofacial syndromes, maintained good oral hygiene, and had a probing depth of less than 3 mm. A written informed consent was obtained prior to the start of orthodontic treatment from each selected individuals.

A standardized treatment protocol of 0.014" nickel titanium (NiTi) (G&H wire company, Europa Form I), 0.016" NiTi, and 0.016" \times 0.022" NiTi was used for initial leveling and aligning. This was followed by the 0.017" \times 0.025" stainless steel (SS) wire with which canine retraction was initiated. A random side (right or left, group I) was chosen for piezocision for a given patient while the contralateral side served as control (group II).

Piezocision was done immediately following extraction of the first premolars in the maxillary arch. A unit (Acteon) and handpiece with curved tip was used. The canine and premolar region was anesthetized using 2% lidocaine with adrenaline. An incision was made mesial and distal to the canine. The tip was inserted to a depth of 3 mm (standardized by markings on the tip) and length of 4–5 mm perpendicular to the cortical bone. The same piezocision procedure was carried out by one operator for all patients. Any side, right or left, was chosen at random for the procedure (Fig. 1).

The GCF fluid was collected with the 1–5 μ L calibrated volumetric microcapillary pipette. The micropipette was placed in the mesial, central, and distal buccal crevicular region to collect 1 μ L of fluid. Samples were collected before starting retraction (T_0), day 1, 3, 7, 14, 21, 42, 60, and 90 (T_{1-9}) or till end of retraction, whichever occurred first (Fig. 2).

Following the procedure, canines on both sides were ligated to the 0.017" \times 0.025" SS wire. Retraction was carried out with a power chain placed from the canine bracket to the molar hook. Both maxillary molars were ligated to reinforce anchorage. A force

of nearly 150 g as suggested by Reitan¹¹ was applied on both sides. The power chain was changed every 4 weeks on both sides until the end of retraction (Fig. 3).

Measurements

Measurement of tooth movement was done using dental casts made immediately before retraction and post completion. The mid-palatine raphe (MPR) drawn from two points, namely, one on the distal aspect of incisive papilla and the second at the posterior border of the raphe near fovea centralis and the rugae line (RL) formed by a projection from the most medial point on the third rugae, was used as reference in accordance with a previous study.⁸ To measure anteroposterior canine movement, a line joining the canine cusp tip and RL (called DC) was measured. Distance between the mesial contact point of the molar and RL (called DM) indicated molar movement or anchorage loss. Angle between the MPR and a line joining the mesial and distal edges of the canine indicated canine rotation. Measurements were made every 4 weeks on a cast using digital Vernier calipers (Fig. 4).

The GCF sample preparation was done by adding 100 μ L buffer to the collected sample in a vial and transferred to the laboratory after being sealed and labeled. It was centrifuged for 1 minute to remove any cellular debris and bacteria. Quantitative enzyme levels were then assayed using commercially available kits (Agappe kits). Acid phosphatase was assessed by mixing 2 mL of the working solution with 0.03 mL of the sample at 25°C and allowed to stand for 5 minutes. Spectrophotometer readings were obtained at the beginning (A1) and at the end of 5 minutes (A2). The mean value A was calculated as $A_2 - A_1$. Alkaline phosphatase was assayed by calculating the absorbance change per minute at 405 nm at 37°C. Absorbance reading was obtained at 1, 2, and 3 minutes.

Statistical Analysis

Data were analyzed using IBM Statistical Package for Social Sciences (SPSS) version 22. Descriptive statistics were represented as mean and standard deviation. The paired "t" test was used to compare the changes between the two groups. A *p* value less than 0.05 was considered significant and *a* value below 0.001 was considered highly significant.

RESULTS

The measurements (DC, DM) between both groups were statistically insignificant. Measurement at T_0 showed no significant difference. The rate of retraction in the first month i.e., T_1 showed significant



Fig. 1: Piezocision done on mesial and distal side of canine

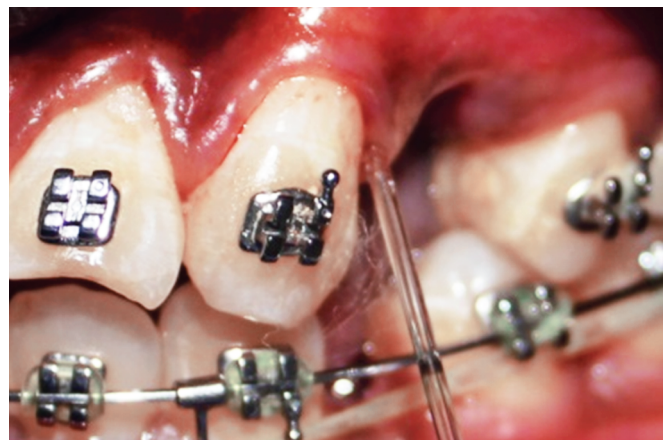


Fig. 2: Collection of gingival crevicular fluid with a micropipette



Fig. 3: End of canine retraction

change in both groups (p value 0.001). The rate of canine retraction in both groups was highly significant from T_0 to T_6 (Table 1). Overall, group I showed a rate of tooth movement 1.5 times that of group II. No statistically significant anchor loss was seen in either group between T_0 and T_6 (Table 2). There was no significant canine rotation from T_0 to T_6 in either groups or between both groups (Table 3).

The quantitative analysis of enzyme ACP levels showed significant differences between both groups. The values peaked at T_3 for both the groups followed by a decline till T_8 (Table 4 and Fig. 5). Values of group I were highly statistically significant ($p < 0.001$) compared to group II at all stages except T_0 .

The enzyme ALP levels showed no significant difference at the pre-retraction stage among the groups. The ALP levels in both groups increased and peaked at T_5 and gradually declined till T_8 (Table 5 and Fig. 6). The levels in the experimental side were significantly higher ($p < 0.001$) than the control group at every interval except T_0 .

The results indicate that the rate of canine retraction was accelerated by 1.5 times by the use of piezocision along a recent extraction site. The enzyme levels on the intervention side increased significantly more than the control side, suggesting increased bone turnover at the same site.

DISCUSSION

With the increasing average age of the orthodontic patient, bone turnover and cell mobilization and consequently the rate of tooth movement is slower. The rigid bone in adults makes them more prone to periodontal problems when compared to growing children. Treatment time for a patient may range from 12 to 36 months depending on the system used and the biological response elicited. Long-term treatment may lead to periodontal complications, white spot lesions, and reduced patient compliance.

Among the various techniques available for accelerating tooth movement and thus reducing treatment time, piezocision is considered an effective and relatively noninvasive procedure. It is indicated in cases of Class I malocclusion with moderate to severe crowding, for correction of deep bites, selected Class II malocclusions, rapid tooth movement in adults, and simultaneous correction of osseous and mucogingival defects that are present or their prevention.⁴ It is not advised for ankylosed teeth, patients with active periodontal disease, and those with conditions affecting bone turnover.⁵

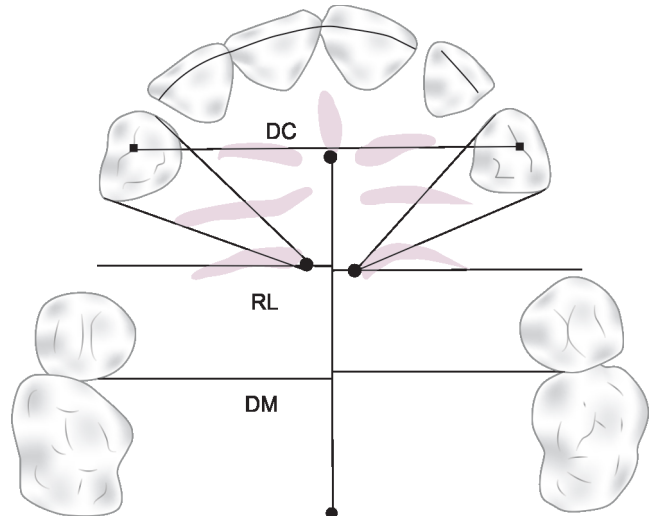


Fig. 4: Measurements in the dental cast

In the present study, the split-mouth technique was used to assess the rate of canine retraction and associated relevant biochemical changes occurring in the tissues via the GCF. The rate of canine retraction was significantly higher on the piezocision side compared to the control. These results were correlated to the studies by Abbas,¹⁰ Iino,¹² and Moon.¹³ This study recorded a rate of tooth movement nearly 1.5 times compared to the control. This was not as high as that seen by Aksakalli,¹⁴ who found the rate to be two times, probably due to the RAP in the recent extraction sites in our study. Bilateral extractions were done immediately prior to retraction, which affected the RAP on both sides. Despite the advantage, the side with piezocision showed greater rate of tooth movement. This was probably due to more extensive injury to the bone in these areas. As suggested by Frost¹ and Wilcko,¹⁵ more severe the bone injury, more vigorous the healing and faster the tooth movement.

Anchor loss was minimal on either side. Second molars were banded in order to increase the anchorage value. Piezocision has been demonstrated to have no effect on the anchorage.^{10,16} It is possible that the presence of the anchor teeth away from the site of extraction and piezocision were responsible for insignificant anchor loss. This highlights the localized or regional aspect of the RAP regardless of the severity of the injury.

No significant rotation of the canine on either side was observed. This was probably due to the use of a 0.017" × 0.025" archwire that reduces the amount of tipping that occurs in a 0.022" slot compared to the 0.016 × 0.022" wire.

Periodontal health plays an important role in tooth movement. The presence of active periodontal disease is a contraindication for orthodontic tooth movement. The immune response caused by periodontal pathogens leads to increase in inflammation, cytokine production, and bone resorption. Orthodontic tooth movement requires bone remodeling in a balanced environment but in periodontal disease this balance is disrupted.¹⁷ Maintaining periodontal health is especially important in adult patients who may have a history of periodontal disease and could have subideal bone levels. Certain factors such as the history of disease, gingival biotype, width of attached gingiva, and presence of recession increase the risk of developing periodontal problems during orthodontic treatment and require regular monitoring.¹⁸

Table 1: Comparison of canine retraction between group I and group II

Time	Group	n	Mean (mm)	Std. deviation	Mean difference	95% confidence interval of the difference		T	p
						Lower	Upper		
T ₀	I	15	12.333	1.6762	-0.2333	-0.5364	0.0697	-1.651	0.121
	II	15	12.567	1.6539					
T ₁	I	15	11.440	1.5883	-0.5533	-0.8277	-0.2789	-4.325	0.001
	II	15	11.993	1.7219					
T ₂	I	15	10.660	1.5878	-0.7867	-1.0554	-0.5179	-6.278	<0.001
	II	15	11.447	1.6847					
T ₃	I	15	9.940	1.6309	-1.0667	-1.3832	-0.7502	-7.228	<0.001
	II	15	11.007	1.7157					
T ₄	I	15	9.187	1.7860	-1.3600	-1.8312	-0.8888	-6.190	<0.001
	II	15	10.547	1.7361					
T ₅	I	13	8.462	1.8910	-1.4615	-2.0518	-0.8712	-5.395	<0.001
	II	13	9.923	1.8130					
T ₆	I	11	7.727	1.7246	-1.4000	-2.2073	-0.5927	-3.864	0.003
	II	11	9.127	1.3624					

Table 2: Comparison of anchor loss between groups

Time	Group	n	Mean (mm)	Std. deviation	Mean difference	95% confidence interval of the difference		T	p
						Lower	Upper		
T ₀	I	15	13.973	2.2292	0.0333	-0.6285	0.6951	0.108	0.916
	II	15	13.940	1.9360					
T ₁	I	15	13.967	2.2340	0.0400	-0.6218	0.7018	0.130	0.899
	II	15	13.927	1.9315					
T ₂	I	15	13.927	2.2682	0.0467	-0.6341	0.7274	0.147	0.885
	II	15	13.880	1.9549					
T ₃	I	15	13.887	2.2778	0.0733	-0.6304	0.7771	0.223	0.826
	II	15	13.813	1.9697					
T ₄	I	15	13.887	2.2778	0.0867	-0.6147	0.7880	0.265	0.795
	II	15	13.800	1.9647					
T ₅	I	13	13.600	2.3241	0.1769	-0.6648	1.0187	0.458	0.655
	II	13	13.423	1.9335					
T ₆	I	11	13.950	2.2092	0.4300	-0.5873	1.4473	0.956	0.364
	II	11	13.520	1.9031					

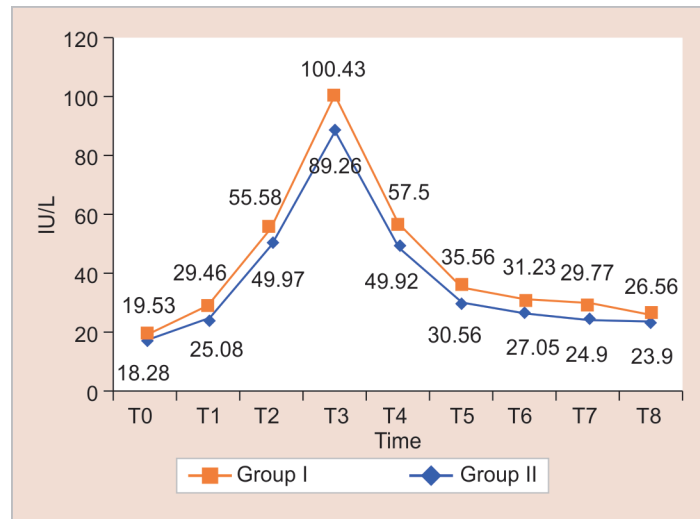
Table 3: Canine rotation observed in both groups

Time	Group	n	Mean (degree)	Std. deviation	Mean difference	95% confidence interval of the difference		t	p
						Lower	Upper		
T ₀	I	15	37.860	0.7039	-0.1067	-0.3503	0.1369	-0.939	0.364
	II	15	37.967	0.5984					
T ₁	I	15	37.800	0.7131	-0.1000	-0.3581	0.1581	-0.831	0.420
	II	15	37.900	0.6141					
T ₂	I	15	37.773	0.6912	-0.1000	-0.3468	0.1468	-0.869	0.399
	II	15	37.873	0.6193					
T ₃	I	15	37.713	0.7463	-0.1267	-0.3808	0.1275	-1.069	0.303
	II	15	37.840	0.6069					
T ₄	I	15	37.700	0.7435	-0.1267	-0.3808	0.1275	-1.069	0.303
	II	15	37.827	0.6029					
T ₅	I	13	37.585	0.7255	-0.1846	-0.4668	0.0976	-1.425	0.180
	II	13	37.769	0.6250					
T ₆	I	11	37.570	0.7903	-0.1800	-0.5642	0.2042	-1.060	0.317
	II	11	37.750	0.6671					

Table 4: Comparison of acid phosphatase levels between groups

Time	Group	n	Mean (IU/L)	SD	Mean difference	t	df	p value
T ₀	II	15	18.28	1.07	1.25	3.28	9	0.009*
	I	15	19.53	0.97				
T ₁	II	15	25.08	1.23	4.38	9.59	9	<0.001*
	I	15	29.46	0.76				
T ₂	II	15	49.97	1.56	5.61	11.32	9	<0.001*
	I	15	55.58	1.24				
T ₃	II	15	89.26	1.22	11.17	22.9	9	<0.001*
	I	15	100.43	1.31				
T ₄	II	15	49.92	0.95	7.58	15.57	9	<0.001*
	I	15	57.50	1.15				
T ₅	II	15	30.56	1.33	5	25.07	9	<0.001*
	I	15	35.56	0.99				
T ₆	II	15	27.05	1.24	4.18	11.59	9	<0.001*
	I	15	31.23	0.94				
T ₇	II	15	24.90	0.78	4.87	12.48	9	<0.001*
	I	15	29.77	1.09				
T ₈	II	15	23.90	0.74	2.66	10.08	9	<0.001*
	I	15	26.56	0.71				

* $p < 0.05$ statistically significant; $p > 0.05$ nonsignificant


Fig. 5: Levels of acid phosphatase

The GCF contains markers such as proteins, enzymes, and metabolites, which can be used to assess the state of the periodontium. Of these, enzymes associated with bone turnover, i.e., ALP for bone formation and ACP for bone resorption, are of particular interest to an orthodontist.⁷ The levels of ACP and ALP are altered in periodontal disease due to disruption of normal bone turnover.¹⁹ Thus, patients with a gingival score of 1 or below were selected.

Values for ALP were higher on the piezocision side at baseline but insignificant. At T₂ and T₃, the values increased on both sides but were higher on the piezocision side suggesting increased osteoblastic activity. Enzyme levels peaked at T₅ (day 21) suggesting the highest rate of bone formation at this time. The ALP levels declined hereon; however, the levels on the piezocision side were constantly higher than the control. This indicates a higher rate of bone formation, possibly due to a more rapid rate of tooth

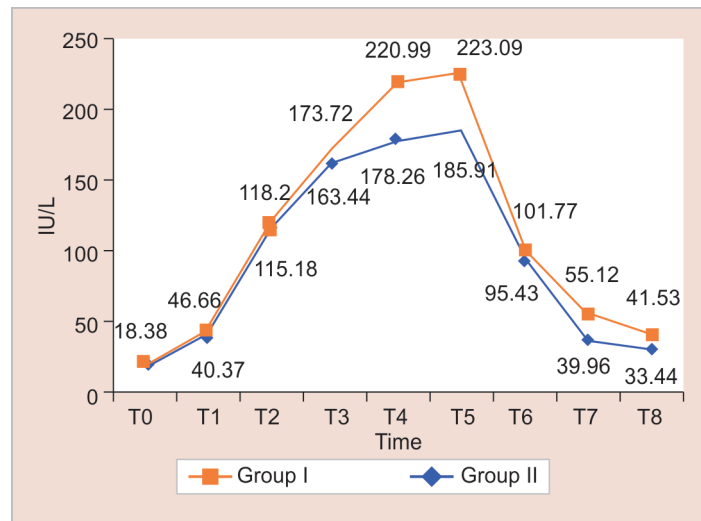
movement on the experimental side. Perinetti et al.¹⁹ similarly found highest values on the 14th day on the mesial side and 21st day on the distal side. These trends cannot be compared to our study as the samples were collected from all surfaces on the canine.

Acid phosphatase levels were similar and the lowest at baseline (T₀). The values increased on following days and peaked at T₃ (day 7). Similar results were reported by Batra et al.²⁰ who found increased values on the 7th day. They however collected samples from the mesial side. Shetty et al.²¹ reported ACP values highest in the 1st and 2nd weeks. In the present study, the values declined henceforth. Other studies such as that by Farahani et al.²² demonstrated peak levels at T₄ (day 14) but did not measure levels at T₃ (day 7). Similar to this study, the ACP levels declined on both sides from day 14. Highly significant differences of ACP levels between both sides at all times except baseline suggest a higher bone turnover rate on the piezocision side.

Table 5: Comparison of ALP levels between groups at different time intervals

Time	Group	n	Mean (IU/L)	SD	Mean difference	t	df	p value
T ₀	II	15	18.99	0.92	-0.61	-1.72	9	0.12 (NS)
	I	15	18.38	0.69				
T ₁	II	15	40.37	0.96	3.29	9.8	9	<0.001*
	I	15	43.66	0.56				
T ₂	II	15	115.18	0.94	3.02	7.47	9	<0.001*
	I	15	118.20	0.77				
T ₃	II	15	163.44	1.13	10.28	20.15	9	<0.001*
	I	15	173.72	1.07				
T ₄	II	15	178.26	0.86	42.73	68.88	9	<0.001*
	I	15	220.99	1.54				
T ₅	II	15	185.91	1.21	39.78	71.22	9	<0.001*
	I	15	225.69	0.95				
T ₆	II	15	95.43	0.81	6.34	11.94	9	<0.001*
	I	15	101.77	1.47				
T ₇	II	15	39.96	1.14	15.16	29.2	9	<0.001*
	I	15	55.12	1.43				
T ₈	II	15	33.44	1.55	8.09	7.58	9	<0.001*
	I	15	41.53	2.56				

* $p < 0.05$ statistically significant; $p > 0.05$ nonsignificant

**Fig. 6:** Levels of alkaline phosphatase

The clinical and the biochemical findings in the study strongly reinforce each other. The rate of tooth movement was higher on the piezocision side, which was reflected in the levels of both ALP and ACP. Despite the RAP in play on both sides, the piezocision side showed an increase in both tooth movement and enzyme levels. The enzyme levels detected were greater than those found in similar studies of tooth movement.^{21,23} The increased levels of ALP and ACP found in the present study may be attributed to the RAP due to recent tooth extraction.

The rate of canine retraction may vary according to several factors that are not considered in the present study. However, being a split-mouth study, the biological factors may have been neutralized to a great extent. The present study did not consider the effect of different force levels on the rate of canine retraction following the piezocisions. Further studies are required to assess

the effect of piezocision on the rate of tooth movement and their long-term stability as well as the gingival status over a period of time. The effect of an increased rate of tooth movement on root resorption also needs to be studied. The enzyme changes and the biochemical effects on the GCF of surrounding teeth may also present an avenue for further research.

CONCLUSION

Taking into account the limitations of the study, piezocision can be an effective procedure for aiding increased rate of tooth movement when used in conjunction with recent extraction sites. The clinical result of increased tooth movement is supported by similar changes in biochemical reaction reflected by the levels of enzymes in the GCF. The procedure would be highly beneficial especially in adult patients seeking orthodontic treatment.

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