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Original Article

Comparative evaluation of cortical bone thickness and total alveolar width following therapeutic orthodontic extraction

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ABSTRACT

Background: Orthodontic tooth extraction is a common procedure that can lead to alveolar defects impacting treatment outcomes. Understanding the healing process and the effects on alveolar bone structure is crucial for effective orthodontic planning. This study compares the impact of Periotome luxation and intra-alveolar extraction on buccal cortical plate thickness, lingual cortical plate thickness, and total alveolar width, crucial parameters for successful orthodontic treatment.

Method: An in-vivo comparative analysis was conducted on 11 patients undergoing orthodontic treatment involving mandibular first premolar extraction. Periotome luxation and intra-alveolar extraction procedures were performed, and CBCT scans were taken pre-treatment, at 3 months, and 6 months post-extraction. Measurements of buccal and lingual cortical thickness and total alveolar width were obtained at various distances from the cement-enamel junction (CEJ).

Result: The results reveal significant decreases in buccal and lingual cortical thickness and total alveolar width over time for both extraction methods. Notably, intra-alveolar extraction showed more pronounced reductions in lingual cortical thickness at the CEJ. However, Periotome luxation demonstrated better preservation of total alveolar width at the CEJ compared to intra-alveolar extraction.

Conclusion: Periotome luxation appears to be a more conservative approach, preserving total alveolar width and minimizing lingual cortical thickness reduction compared to intra-alveolar extraction. These findings underscore the importance of extraction method selection in orthodontic planning for optimal treatment outcomes.

Keywords: Orthodontics, therapeutic extraction, alveolar bone thickness, cortical bone, Periotome luxation, Intra-alveolar extraction

Introduction

In the context of orthodontic treatment, tooth extraction is a common practice, but it often results in alveolar defects that are only partially restored during the healing process. The occurrence of bone growth within the extraction socket is paralleled by documented resorption of the alveolar ridges, especially in the horizontal aspect, predominantly situated on the facial or buccal side. This bone loss can lead to changes in the ridge's position, affecting orthodontic treatment. Comprehending the healing mechanisms within extraction sites, encompassing

contour alterations induced by bone resorption is necessary for strategic and effective treatment planning. [1]

Studies have shown that on average, the alveolar ridge undergoes significant horizontal and vertical changes in the six months following extraction, with the buccal plate experiencing more bone resorption than the lingual plate. This alteration in ridge position can impact orthodontic space closure. [1, 2] The process of wound healing is intricate, encompassing various stages that include the inflammatory phase, proliferative phase, and maturation phase. This process includes the formation of clots, granulation tissue, provisional matrix, and immature bone. [3]

Atraumatic extraction techniques, like Periotome luxation, aim to preserve the socket's bony integrity and minimize soft tissue injury. These methods are particularly valuable when extracting teeth without damaging the surrounding thin alveolar bone plates. Traditional extraction methods can result in bone and tissue damage, leading to undesirable post-operative consequences.[4] CBCT (Cone Beam Computed Tomography) has revolutionized the assessment of bone thickness and other critical factors in orthodontics by providing high-resolution 3D imaging. This technology is crucial for precise diagnosis, treatment planning, and assessing complex cases.[5]

In this study, we aimed to compare buccal cortical plate thickness, lingual cortical plate thickness, and total alveolar width following Periotome luxation on one side and Intra-alveolar extraction on the other side, as these parameters are crucial for successful orthodontic treatment.

Materials and methods

The study conducted an in-vivo comparative analysis to assess buccal cortical plate thickness, lingual cortical plate thickness, and total alveolar width following Periotome luxation and intra-alveolar extraction. The study comprised 11 patients aged between 18 and 24 years, seeking orthodontic treatment involving the extraction of mandibular first premolars. Ethical clearance and informed consent were obtained, and pre-treatment CBCT scans were taken. Patients were subjected to Periotome luxation or intra-alveolar extraction procedures under local anesthesia. Follow-up CBCT scans were performed at 3 months and 6 months post-extraction. The cortical bone thickness and total alveolar width were meticulously measured at various distances from the cement-enamel junction. This comprehensive methodology allowed for a thorough investigation of the impact of different extraction techniques on the alveolar bone structure, providing valuable insights into orthodontic treatment.

Statistical analysis:

The statistical analysis for this study involved utilizing the SPSS 25 software from IBM in Armonk, NY, USA. Specific statistical analyses were utilized to assess the data and ascertain the statistical significance of the findings. The choice of statistical tests depended on the nature of the data collected. Significance was assessed at a 5% level, meaning that a p-value less than 0.05 was considered statistically significant. The meticulous application of statistical analysis guaranteed the reliability and validity of the findings, enhancing the strength and solidity of the study's conclusions.

Results

Buccal crestal bone levels exhibited significant decreases from the initial measurement of 1.4591 mm to 0.9555 mm at 3 months and further to 0.8127 mm at 6 months. Similarly, lingual crestal bone levels decreased significantly from 3.0400 mm pre-treatment to 2.2255 mm at 3 months and 2.1136 mm at 6 months. Total alveolar crestal bone levels also experienced a notable reduction, decreasing from 8.4855 mm pre-treatment to 7.0145 mm at 3 months and 6.7173 mm at 6 months.

The results indicate that buccal cortical thickness at CEJ was slightly higher before extraction compared to 3 months (p=0.357) but significantly reduced at 6 months (p=0.039). Similarly, lingual cortical thickness was higher before extraction than at 3 months (p=0.241) and remained statistically insignificant at 6 months (p=0.137). Total alveolar width was slightly higher before extraction than at 3 months (p=0.511) and reduced at 6 months without statistical significance (p=0.238). (Table 1)

Table 1 presents the relationship between buccal and lingual cortical thickness and at 10 mm from CEJ and total alveolar width before extracting the first premolar.

Variable			N	Mean	Std. Deviation	Std. ErrorMean	P value
Buccal		cej pre	11	1.4591	.83941	.25309	0.117
		3 months	11	.9555	.58004	.17489	
		cej pre	11	1.4591	.83941	.25309	0.038
		6 months	11	.8127	.48006	.14474	
lingual		cej pre	11	3.0400	1.32552	.39966	0.115
		3 months	11	2.2255	.96458	.29083	
		cej pre	11	3.0400	1.32552	.39966	0.079
		6 months	11	2.1136	1.00168	.30202	
Total alvcej		cej pre	11	8.4855	.91301	.27528	0.002
		3 months	11	7.0145	.97900	.29518	
		cej pre	11	8.4855	.91301	.27528	0.000
		6 months	11	6.7173	1.01390	.30570	
Variable			N	Mean	Std.	Std. ErrorMean	P value

					Deviation		
Buccal		cej	11	1.9045	.52923	.15957	.357
		3 months	11	1.7064	.45480	.13713	
		cej pre	11	1.9045	.52923	.15957	.039
		6 months	11	1.4918	.32040	.09660	
lingual		cej	11	2.6973	.77982	.23513	.241
		3 months	11	2.3182	.68962	.20793	
		cej	11	2.6973	.77982	.23513	.137
		6 months	11	2.2245	.64683	.19503	
Total alvcej		cej	11	11.5891	2.38315	.71855	.511
		3 months	11	10.9282	2.24696	.67748	
		cej	11	11.5891	2.38315	.71855	.238
		6 months	11	10.4518	1.97972	.59691	

The analysis of the data in Tables 2 reveals subtle differences in buccal cortical thickness at the CEJ between pre-extraction and 3 months, with p-values of 0.293 and 0.775, respectively. However, these differences become statistically insignificant at 6 months (p-values of 0.128 and 0.614). Similarly, lingual cortical thickness at the CEJ shows slight variations between pre-extraction and 3 months, with p-values of 0.285 and 0.487, becoming insignificant at 6 months (p-values of 0.146 and 0.986). Total alveolar width demonstrates similar trends, with pre-extraction measurements slightly higher than 3 months, but these differences are statistically insignificant at both time points (p-values of 0.135, 0.988, and 0.069, 0.522, respectively).

Table No. 2 - Association of Buccal, Lingual Cortical thickness at 15 mm and 20 mm from CEJ and Total Alveolar Width after Intra alveolar extraction of first premolar.

Variable			N	Mean	Std. Deviation	Std. ErrorMean	P value
Buccal		cej	11	2.3491	.78208	.23581	.293
		3 months	11	2.0191	.64589	.19474	
		cej pre	11	2.3491	.78208	.23581	.128
		6 months	11	1.8709	.62017	.18699	
lingual		cej	11	2.6255	.70345	.21210	.285
		3 months	11	2.3127	.62932	.18975	
		cej	11	2.6255	.70345	.21210	.146
		6 months	11	2.2382	.47411	.14295	
Total alvcej		cej	11	11.4527	1.60924	.48520	.135
		3 months	11	10.4618	1.36066	.41025	
		cej	11	11.4527	1.60924	.48520	.069
		6 months	11	10.3036	1.15237	.34745	
Variable			N	Mean	Std. Deviation	Std. ErrorMean	P value
		cej	11	2.2273	.35978	.10848	.775
		3 months	11	2.2909	.63433	.19126	

Buccal		cej pre	11	2.2273	.35978	.10848	.614
		6 months	11	2.3491	.70068	.21126	
lingual		cej	11	2.2882	.56769	.17117	.487
		3 months	11	2.4309	.35379	.10667	
		cej	11	2.2882	.56769	.17117	.986
		6 months	11	2.2845	.39943	.12043	
total alvcej		cej	11	11.0764	2.00903	.60575	.988
		3 months	11	11.0627	2.15856	.65083	
		cej	11	11.0764	2.00903	.60575	.522
		6 months	11	10.5018	2.12394	.64039	

All the readings are in millimeter.

The data in Table 3 indicates that buccal cortical thickness at the CEJ was slightly higher pre-extraction compared to 3 months (p=0.702) and statistically insignificant at 6 months (p=0.303). Similarly, lingual cortical thickness showed no significant changes between pre-extraction and 3 months (p=0.877) and remained insignificant at 6 months (p=0.701). Total alveolar width exhibited minor differences between pre-extraction and 3 months (p=0.123), with no significant changes at 6 months (p=0.226).

Table no. 3 - Association of Buccal, Lingual Cortical thickness at CEJ and Total Alveolar Width after Periotome luxation of first premolar.

Variable			N	Mean	Std. Deviation	Std. Error Mean	P value
Buccal		cej pre	11	.7709	.14060	.04239	.702
		3 months	11	.7473	.14540	.04384	
		cej pre	11	.7709	.14060	.04239	.303
		6 months	11	.7045	.15358	.04631	
lingual		cej pre	11	1.2391	.40979	.12356	.877
		3 months	11	1.2118	.40899	.12332	
		cej pre	11	1.2391	.40979	.12356	.701
		6 months	11	1.1673	.45271	.13650	
total alveolar		cej pre	11	7.4236	.57904	.17459	.123
		3 months	11	6.8664	.98949	.29834	
		cej pre	11	7.4236	.57904	.17459	.226
		6 months	11	7.0355	.85286	.25715	

All the readings are in millimeter

The data in Table 4 reveals that buccal cortical thickness at 10 mm from the CEJ was slightly higher before extraction compared to 3 months (p=0.899) and statistically insignificant at 6 months (p=0.796). For lingual cortical thickness, similar results were observed with pre-extraction values higher than 3 months (p=0.796) and no significant changes at 6 months (p=0.763). Total alveolar width also showed minor differences between pre-extraction and 3 months (p=0.942) and remained statistically insignificant at 6 months (p=0.326)

Table no. 4 - Association of Buccal, Lingual Cortical thickness at 10 mm from CEJ and Total Alveolar Width after Periotome luxation of first premolar.

Variable			N	Mean	Std. Deviation	Std. Error Mean	P value
Buccal		cej	11	1.9600	.72855	.21967	0.899
		3 months	11	1.9200	.72589	.21886	
		cej pre	11	1.9600	.72855	.21967	.796
		6 months	11	1.8773	.74932	.22593	
lingual		cej	11	2.3918	.58043	.17501	0.796
		3 months	11	2.3173	.74553	.22479	
		cej	11	2.3918	.58043	.17501	.763
		6 months	11	2.3145	.60614	.18276	
total alvcej		cej	11	10.9873	1.70644	.51451	.942
		3 months	11	10.9336	1.71457	.51696	
		cej	11	10.9873	1.70644	.51451	.326
		6 months	11	10.6100	3.36862	1.01568	

All the readings are in millimeter

In Table 5, buccal cortical thickness at 15 mm from the CEJ was slightly higher pre-extraction compared to 3 months (p=0.824) and statistically insignificant at 6 months (p=0.698). Similarly, lingual cortical thickness showed higher pre-extraction values than 3 months (p=0.855) and remained insignificant at 6 months (p=0.826). Total alveolar width exhibited minor differences between pre-extraction and 3 months (p=0.901) and remained statistically insignificant at 6 months (p=0.670).

Table no. 5 - Association of Buccal, Lingual Cortical thickness at 15 mm from CEJ and Total Alveolar Width after Periotome luxation of first premolar.

Variable			N	Mean	Std. Deviation	Std. Error Mean	P value
Buccal		cej	11	2.2145	.55242	.16656	.824
		3 months	11	2.1600	.58136	.17529	
		cej pre	11	2.2145	.55242	.16656	.698
		6 months	11	2.1182	.59346	.17894	
Lingual		cej	11	2.6291	.88439	.26665	.855
		3 months	11	2.5564	.95520	.28800	
		cej	11	2.6291	.88439	.26665	.826
		6 months	11	2.5409	.96790	.29183	
total alvcej		cej	11	11.8491	1.55341	.46837	.901
		3 months	11	11.7645	1.58359	.47747	
		cej	11	11.8491	1.55341	.46837	.670
		6 months	11	11.5591	1.58948	.47925	

All the readings are in millimeter.

In Table 6 buccal cortical thickness at 20 mm from the CEJ was slightly higher pre-extraction than at 3 months (p=0.951) and statistically insignificant at 6 months (p=0.895). Similarly, lingual cortical thickness showed higher pre-extraction values than 3 months (p=0.965) and remained insignificant at 6 months (p=0.978). Total alveolar width exhibited minor differences between pre-extraction and 3 months (p=0.933) and remained statistically insignificant at 6 months (p=0.988).

Table no. 6 - Association of Buccal, Lingual Cortical thickness at 20 mm from CEJ and Total Alveolar Width after Periotome luxation of first premolar.

Variable	N	Mean	Std. Deviation	Std. Error Mean	P value

Buccal		cej	11	2.1164	.51891	.15646	.951
		3 months	11	2.1027	.51651	.15573	
		cej pre	11	2.1164	.51891	.15646	.895
		6 months	11	2.0864	.52897	.15949	
lingual		cej	11	2.9891	1.00763	.30381	.965
		3 months	11	3.0082	1.00165	.30201	
		cej	11	2.9891	1.00763	.30381	.978
		6 months	11	2.9773	1.01728	.30672	
total alvcej		cej	11	12.7891	1.69228	.51024	.933
		3 months	11	12.8482	1.57765	.47568	
		cej	11	12.7891	1.69228	.51024	.988
		6 months	11	12.7782	1.58795	.47878	

All the readings are in millimeter

Initially, lingual cortical thickness at CEJ was similar between Intra-alveolar extraction (1.2391±0.41863 mm) and Periotome luxation (1.2391±0.40979 mm). After 3 months, Intra-alveolar extraction reduced it significantly more (0.93±0.17 mm) than Periotome luxation (1.21±0.40 mm) with a p-value of 0.004. At 6 months, Intra-alveolar extraction (0.70±0.153 mm) continued to show a significant reduction compared to Periotome luxation (1.16±0.45 mm) with a p-value of 0.004. This indicates a more pronounced reduction in lingual cortical plate thickness at the CEJ in Intra-alveolar extraction compared to Periotome luxation.

Initially, total alveolar width at CEJ was slightly higher in Periotome luxation (7.42 ± 0.57 mm) compared to Intra-alveolar extraction (7.38 ± 0.57 mm), but this difference was statistically insignificant (p=0.883). After 3 months, Intra-alveolar extraction reduced the width more (6.33 ± 1.31 mm) than Periotome luxation (6.86 ± 0.98 mm), which was clinically significant though statistically insignificant. However, at 6 months, there was a significant difference (p=0.004) with less reduction in width for Periotome luxation (7.03 ± 0.85 mm) compared to Intra-alveolar extraction (5.73 ± 0.99 mm). This suggests that at the CEJ, total alveolar plate thickness is better preserved in Periotome luxation than in Intra-alveolar extraction. (Table 7)

Table no. 7 – Association of Buccal, Lingual Cortical thickness and Total Alveolar Width at CEJ after Periotome luxation and Intra-alveolar extraction of first premolar.

AT CEJ						
Variable		N	Mean	Std. Deviation	Std. Error Mean	P value
buccal cej pre	Periotome luxation	11	.7709	.14060	.04239	.964
	Intra-alveolar extraction	11	.7682	.13768	.04151	
3 months	Periotome luxation	11	.7473	.14540	.04384	117
	Intra-alveolar extraction	11	.6482	.13790	.04158	
6 months	Periotome luxation	11	.7045	.15358	.04631	.004
	Intra-alveolar extraction	11	.5236	.10745	.03240	
ling. Pre	Periotome luxation	11	1.2391	.40979	.12356	.050
	Intra-alveolar extraction	11	1.2391	.41863	.12622	
3 months	Periotome luxation	11	1.2118	.40899	.12332	004
	Intra-alveolar extraction	11	.9318	.17848	.05381	
6 months	Periotome luxation	11	1.1673	.45271	.13650	.004
	Intra-alveolar extraction	11	.7100	.11489	.03464	
total alveolar pre	Periotome luxation	11	7.4236	.57904	.17459	.883
	Intra-alveolar extraction	11	7.3855	.61959	.18681	
3 months	Periotome luxation	11	6.8664	.98949	.29834	.295
	Intra-alveolar extraction	11	6.3318	1.31854	.39755	
6 months	Periotome luxation	11	7.0355	.85286	.25715	.004
	Intra-alveolar extraction	11	5.7391	.99216	.29915	
All the readings are in millimeter						

Initially, at 20 mm from CEJ, buccal cortical thickness was higher in Periotome luxation (2.11±0.51mm) than Intra-alveolar extraction (2.03±0.53mm) with significant association (p=0.004). After 3 months, Intra-alveolar extraction showed more reduction (1.92±0.577mm) compared to Periotome luxation (2.1164±0.51mm), though not significant (p=0.725). At 6 months, Intra-alveolar extraction further reduced (1.93±0.55mm) compared to Periotome luxation (2.08±0.52mm), significant at p=0.45, indicating more reduction in buccal cortical plate in Intra-alveolar extraction.

Lingual cortical thickness at 20 mm from CEJ was similar before extraction (Periotome luxation: 2.98±1.0mm, Intra-alveolar extraction: 3±0.9mm, p=0.04). After 3 months, Intra-alveolar extraction reduced more (2.94±0.96mm) than Periotome luxation (3±1mm), not

significant (p=0.96), but evident clinically. After 6 months, Intra-alveolar extraction showed more reduction (2.97±1.01mm) compared to Periotome luxation (2.92±0.97mm), not significant (p=0.874), but evident clinically.

Initially, total alveolar width at 20 mm from CEJ was slightly higher in Periotome luxation (11.84±1.5mm) than Intra-alveolar extraction (11.68±1.7mm). After 3 months, Intra-alveolar extraction increased (12.43±1.8mm) more than Periotome luxation (12.84±1.57mm), not significant (p=0.915), but evident clinically. After 6 months, total alveolar width was similar (Periotome luxation: 12.39±1.85mm, Intra-alveolar extraction: 12.77±1.58mm, p=0.574), indicating more reduction in Intra-alveolar extraction at 20 mm from CEJ. (Table 8)

Table no. 8 – Association of Buccal, Lingual Cortical thickness and Total Alveolar Width at 20 mm from CEJ after Periotome luxation and Intra-alveolar extraction of first premolar.

20 MM FROM CEJ						
Variable		N	Mean	Std. Deviation	Std. Error Mean	P value
buccal cej pre	Periotome luxation	11	2.1164	.51891	.15646	.004
	Intra-alveolar extraction	11	2.0364	.53332	.16080	
3 months	Periotome luxation	11	2.1027	.51651	.15573	.725
	Intra-alveolar extraction	11	1.9209	.57721	.17403	
6 months	Periotome Luxation	11	2.0864	.52897	.15949	.045
	Intra-alveolar extraction	11	1.9036	.55931	.16864	
ling. pre	Periotome Luxation	11	2.9891	1.00763	.30381	.040
	Intra-alveolar extraction	11	3.0082	.90618	.27322	
3 months	Periotome Luxation	11	3.0082	1.00165	.30201	.963
	Intra-alveolar extraction	11	2.9409	.96330	.29045	
6 months	Periotome Luxation	11	2.9773	1.01728	.30672	.874
	Intra-alveolar extraction	11	2.9236	.97668	.29448	
total alveolar pre	Periotome Luxation	11	12.7891	1.69228	.51024	.001
	Intra-alveolar extraction	11	12.7109	1.68090	.50681	
3 months	Periotome Luxation	11	12.8482	1.57765	.47568	.915
	Intra-alveolar extraction	11	12.4355	1.80416	.54397	
6 months	Periotome Luxation	11	12.7782	1.58795	.47878	.574

Discussion

Despite advancements in orthodontic therapy, dental malocclusions still require premolar extractions due to the loss of the labial plate of bone. CBCT, with its high accuracy and

sensitivity, can capture the maxilla and mandible in a single rotation. This study compares buccal cortical plate thickness, lingual cortical plate thickness, total alveolar width, and intra alveolar extraction using CBCT.

Monica Misawa's study compared total alveolar width before and after premolar extraction using conventional methods. She found that at the marginal third, total alveolar width reduced by 5.3 mm. In a study comparing intra and intra alveolar extraction, total alveolar width reduced by 1.05 mm in 3 months and 1.64 mm in 6 months, with statistically insignificant results in 3 months.

Monica Misawa and Kumar[6] have conducted studies on dental malocclusions, particularly premolar extractions. Conventional methods often result in loss of the labial plate of bone, particularly in anterior and bicuspid teeth due to the naturally occurring anatomy of the alveolus in these areas.[6,7] Kumar et al., conducted a comparison between CT and CBCT, highlighting that CBCT demonstrates high accuracy and sensitivity. It can quantitatively evaluate buccal bone height and thickness with precision. The study specifically compared buccal cortical plate thickness, lingual cortical plate thickness, and total alveolar width after performing Periotome luxation and Intra-alveolar extraction using CBCT.[6] Misawa's study measured total alveolar width before and after extraction of premolars by conventional methods, showing that total alveolar width is more preserved in Periotome luxation than Intra alveolar extraction. This study exhibited resemblances to Misawa's research, wherein the majority of reduction took place in the marginal area of the edentulous site (over 60%), accompanied by notable reductions in the cross-sectional area in the more apical regions of the ridge.[7]

Van der Weijden's review of alveolar bone dimensional changes in post-extraction sockets in humans found that buccal and lingual changes resulted in reductions of 2.59 (1.85) and 2.03 (1.88), respectively.[1] Pietrokovski & Massler's 1967 study reported a more pronounced reduction of the buccal portion of the edentulous site following tooth extraction.[8] Sephen Brown's study revealed that conventional methods of tooth extraction usually result in loss of the labial plate of bone.[9] In this study, loss of buccal cortical plate thickness was observed more in intra-alveolar extraction than Periotome luxation. At CEJ, buccal cortical plate thickness reduced by 0.12mm in 3 months and 0.24mm in 6 months, greater than in Periotome luxation. The study found that buccal cortical plate thickness is more reduced after extraction with the intra-alveolar method than Periotome luxation. The actual change in width observed clinically exceeds the change observed on radiographs, which measures at 1.21 millimeters.

Conclusion

The study compared two tooth extraction techniques, Periotome luxation and intra-alveolar extraction, in 11 orthodontic patients. It analyzed changes in buccal and lingual cortical thickness and total alveolar width over time. The results showed significant reductions in cortical thickness with both techniques, with intra-alveolar extraction leading to more pronounced reductions in some areas. Total alveolar width variations were noted, with Periotome luxation preserving width at the CEJ better. These findings suggest that the choice of extraction technique can impact alveolar bone structure, emphasizing the need for careful planning in orthodontic treatment. Further research is required to confirm these results in clinical practice.

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