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Original Article

Comparative Outcomes of Arch Widening and Extraction Therapies in Managing Mandibular Arch Crowding: An Orthodontic Perspective

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ABSTRACT

Background: Orthodontic extraction therapy is frequently used to manage mandibular arch crowding. However, its long-term effects on clinical crown length and gingival recession remain unclear, particularly in cases of mild crowding. The present research was design to assess the choice of treatment modality (extraction vs. non-extraction) on the prevalence of labial gingival recession and changes in clinical crown lengths in mandibular anterior teeth.

Methods: A retrospective, longitudinal study was conducted on 70 patients undergoing orthodontic treatment at Albaha University. Patients were divided into extraction (X, n=44) and non-extraction (WE, n=26) groups, ensuring a balanced representation. Inclusion criteria included Angle's Class I malocclusion with mild to moderate mandibular crowding, and a minimum retention period of three years. Clinical crown lengths were measured with precise digital calipers at three-time points: before treatment (T1), post-debonding (T2), and final retention (T3). Cephalometric analysis was performed with skeletal and dental parameters. Data and the analyzed outcomes were assessed.

Results: Both groups showed a significant increase in clinical crown lengths from T1 to T3 ($p < 0.05$), with the increase being more pronounced for canines. No statistically significant difference in gingival recession or crown lengthening was observed between the X and WE groups at retention ($p = 0.787$). Cephalometric variables (D1, D2, and D3) were significantly associated with the extraction decision, particularly at the debonding and retention stages ($p < 0.05$). However, the vertical cranial morphology did not influence treatment decisions.

Conclusion: There was no significant difference in the development of gingival recession between extraction and non-extraction groups. Extraction therapy was associated with longer treatment duration but did not directly cause increased recession.

Keywords: Orthodontic Extraction, Mandibular anteriors, retention monitoring period, Canine and anterior crown.

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INTRODUCTION

Mandibular anterior crowding is a common orthodontic concern, particularly in patients with sagittal dental alignment of Angle Class I (neutral occlusion). Its prevalence varies widely across populations, mainly due to ethnic differences, making global prevalence estimates challenging to standardize. [1] Treatment options for mandibular crowding range from arch lengthening or widening Intercanine distance to more invasive approaches such as tooth extraction or interproximal enamel reduction. While extractions are typically reserved for severe cases, although interproximal enamel reduction is often the preferred method for severe cases, widening the intercanine distance is considered less stable.[4]

Orthodontic tooth movement, particularly in the mandibular region, poses significant implications for periodontal health due to the delicate nature of the supporting tissues with associated biomechanical stresses. These stresses can result in adverse outcomes, including marginal bone loss, gingival recession, and gingival atrophy. [5]

The inadequate remodelling can expose the root surface, increasing the risk of gingival recession and other periodontal complications due to reduced bone support. Additionally, prolonged or aggressive tooth movement can disrupt the blood supply to periodontal tissues, further compromising both alveolar bone and gingival health. [6]

The relationship between orthodontic tooth movement and gingival recession remains debated, partly due to conflicting evidence and methodological limitations. A notable gap in the literature is the absence of standardized assessments of baseline crowding, which significantly influences tooth movement and periodontal outcomes. Long-term studies addressing these variables are crucial for understanding the impact of orthodontic treatment on gingival recession development. [7] The present study was aimed to compare long-term outcomes of cases treated with extraction (X) to those treated without extraction (WE).

MATERIALS AND METHODS

A retrospective, cross-sectional comparative study was conducted on 100 patients undergoing orthodontic treatment at the Dental Department of the University Medical Center, Albaha University, Saudi Arabia. The study adhered to the ethical guidelines for human research outlined by the Research Ethics Committee of Albaha University. Written informed consent was obtained from all patients and their legal guardians.

Using the G power (vs3.1.2) software, with a calculated effect size of 0.671, 80% power, and 95% confidence interval, 70 patients met these inclusion criteria, with 26 in the non-extraction group (WE) and 44 in the extraction group (X). Participants were selected based on specific criteria: a Class I molar and canine relationship with crowding in the lower anterior region, completion of orthodontic treatment with fixed appliances, absence of developmental anomalies or dental pathological lesions in the lower jaw confirmed by an expert oral pathologist, discharge from retention controls between January 2022 and January 2023, availability of complete documentation including medical history, study models, and cephalometric images at three time points (prior to treatment [T1], immediately after debonding [T2], and at the final retention [T3]), no history of oral surgery, interdental stripping, or extraction of lower anterior or molar teeth, a minimum of three years of retention time between T2 and T3, and initial complete eruption of permanent dentition (up to the first molar) with moderate crowding measured by Little’s Irregularity Index (4-9 mm), and Angle Class I molar occlusion (patients with molar deviations greater than ½ Class II or ¼ Class III were excluded).

Data Collection

Study models and cephalometric X-rays from T1, T2, and T3 were retrieved from archived patient records for each patient. The patient's age at the start and end of treatment and retention documentation were obtained from medical records. The duration of active treatment, defined as the time between the placement of fixed appliances and debonding, was calculated.

Measurements

Study Models:

- Crowding Assessment: Lower anterior crowding was assessed using Little’s Irregularity Index, [9] which quantifies the sum of the displacements of the contact points of the six mandibular anterior teeth in an occlusal view.

- Clinical Crown Length: The clinical crown length of the lower anterior and canine teeth was measured using a digital caliper (precision of two decimal places) from the lowest point of the gingival margin (margo gingivae) to the cusp tip of the canines or the incisal edge of the anterior teeth. Over time, an increase in clinical crown length was interpreted as gingival recession. [10]

Cephalometric Analysis: Cephalometric radiographs (T1, T2, T3) were traced using a 0.3 mm H1-Fix pencil on 0.14 mm acetate film (Forma). Double contours from paramedian structures were recorded and averaged during computerized analysis. Skeletal and dental measurements were taken as per standard cephalometric landmarks.

Figure 1: Occlusal view

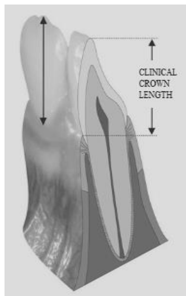

Figure 2. Incisal edge of the anterior teeth

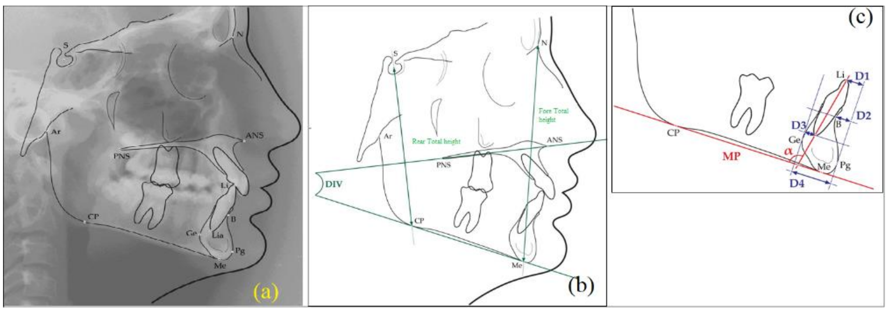

Figure 3**: (a)** the cephalometric reference points**; (b) & (c)** Cephalometric measurements described

Legends (Fig: 3)

- Apex (Lia); Articulare (Ar); B point (B); Corpus Tangent Point (CP); Genion (Ge); Incisal (Li); Menton (Me); Nasion (N); Pogonion (Pg); Sella (S); Anterior nasal spine (ANS) and Posterior Nasal Spine (PNS)

- N-Me (Distance between Nasion and Menton)

- S-CP (Distance between Sella and Corpus tangent point)

- D1(Distance between Li and the tangent to Pg perpendicular to MP)
- D2(Distance between B and the tangent to Pg perpendicular to MP)
- D3 (Distance between Lia and the tangent to Ge perpendicular to MP)
- D4 (Distance between the tangents to Pg and Ge Angle measurements (in °)
- DIV (jaw base divergence, circumscribed by the angle of the lines)

Statistical data analysis

Data were analyzed using SPSS Version 20. To ensure reliable measurements, intra-person repeatability was assessed through intra-class correlation for absolute agreement, obtained using one-way ANOVA. Descriptive and exploratory statistics were used to characterize the clinical and cephalometric data. The normality of the variables was evaluated with the Kolmogorov-Smirnov test. Group comparability between the extraction (X) and non-extraction (WE) groups was assessed by comparing initial crowding levels, duration of active treatment, and retention time (age at T3). The unpaired Student's t-test or Mann-Whitney U-test was employed to compare treatment time, extraction decisions, and model and cephalometric values. The Levene test was used to compare variances of model parameters. Changes in clinical crown length from T1 to T3 were evaluated for anterior and canine teeth in both groups. Spearman's rank correlation analysis was conducted to explore associations between changes in crown length and various dental, symphyseal, and skeletal variables. Multiple regression models were applied to assess the impact of crowding severity and treatment duration on crown length changes over time, with the adjusted coefficient of determination (R^2) used to evaluate the model's explanatory power. Statistical significance was set at p-values under 0.05.

RESULTS

Reproducibility

Using the intra-class correlation (ICC) [12], a very good reproducibility of all recorded measurements could be demonstrated. The ICC values for cephalometric measurements varied between 0.919 (95% CI: 0.708 - 0.979) and 0.999 (95% CI: 0.998 - 0.999), for plaster model measurements between 0.996 (95% CI: 0.992 - 0.998) and 0.999 (95% CI: 0.998 - 0.999).

Comparability of both groups

Table 1 compares several variables between the extraction (X) and non-extraction (WE) groups, reported as mean (SD). The Little Index at the beginning, which measures initial crowding in millimeters, was 6.04 (1.19) for the X group and 6.4 (1.29) for the WE group. The difference between the two groups was not statistically significant (p = 0.314), indicating that both groups had similar levels of initial crowding.

Table 1. Comparison of different variables of the X and WE groups

	Group	N	Mean	SD	Minimum	Maximum	P value
Little index at the beginning (mm)	X	44	6.04	1.19	4.13	8.77	[a]0.314,ns
	WE	56	6.4	1.29	4.28	8.56	
Duration of treatment (Days)	X	44	738.88	207.2	201	1287	[a]0.001*, sig
	WE	56	488.12	194.71	67	1015	
Retention period (Days)	X	44	2676.13	684.14	1389	4228	[a]0.521,ns
	WE	56	2532.69	864.77	1148	5102	
Age in retention (days)	X	44	8706.5	1032.92	6684	11762	[b]0.394,ns
	WE	56	9052.54	2223.05	6899	15266	

[a] Two-Sample t-Test, [b]Mann Whitney u test level of significance set at $p < 0.05$

Ns: non significant, sig: significant

The duration of treatment was significantly longer in the extraction group, with a mean of 738.88 (207.2) days, compared to 488.12 (194.71) days in the non-extraction group (p = 0.001). This result suggests that extraction treatment typically requires a longer duration.

The retention period, or the time between the end of active treatment and the final follow-up, was comparable between the two groups. The X group had a retention period of 2676.13 (684.14) days, while the WE group had 2532.69 (864.77) days, with no statistically significant difference (p = 0.521).

Lastly, the age at retention was also similar between the groups. The X group had a mean age of 8706.5 (1032.92) days, and the WE group had 9052.54 (2223.05) days, with no significant difference (p = 0.394). Overall, while the groups were similar in terms of initial crowding, retention period, and age at retention, treatment duration was significantly longer for the extraction group.

Change in clinical crown lengths

Table 2 compares crown lengths and changes across different therapy phases for canines and anterior teeth in the extraction (X) and non-extraction (WE) groups.

Table 2: Comparison of Crown Lengths and Differences in the X and WE (tooth level).

Group		Therapy phase	Mean	SD	Minimum	Maximum	The increase from beginning to retention	P value
X	Canine (n=46)	Beginning	8.55	1.36	5.5	11.41	1.02 (0.03)	0.787, ns
		Debond	8.92	1.5	6.28	14.49		
		Retention	9.57	1.39	7.42	13.29		
	Anterior teeth (n=94)	Beginning	7.71	0.78	6.02	10.17	0.42 (0.46)	
		Debond	7.68	0.75	5.94	10.55		
		Retention	8.13	1.04	5.91	12.04		
WE	Canine (n=50)	Beginning	8.6	1.26	6.66	12.46	0.82 (0.3)	
		Debond	8.9	1.22	6.49	12.34		
		Retention	9.42	0.96	7.1	11.23		
	Anterior teeth (n=100)	Beginning	7.79	0.78	6.04	11.35	0.39 (0.15)	
		Debond	7.75	0.88	4.96	11.11		
		Retention	8.18	0.93	6.36	10.98		

[a] Two-Sample t-test, level of significance set at $p < 0.05$

Ns: non significant, sig: significant

In the X group, the mean canine crown length at the beginning was 8.55 mm (SD = 1.36), ranging from 5.5 to 11.41 mm. By the retention phase, it increased to 9.57 mm (SD = 1.39), with a statistically significant increase of 1.02 mm (p = 0.001).

For the anterior teeth in the X group, the mean crown length at the beginning was 7.71 mm (SD = 0.78), ranging from 6.02 to 10.17 mm. By retention, this increased to 8.13 mm (SD = 1.04), with a mean increase of 0.42 mm, though this change was less pronounced than the canines.

In the WE group, the initial mean canine crown length was 8.6 mm (SD = 1.26), ranging from 6.66 to 12.46 mm. By retention, the mean increased to 9.42 mm (SD = 0.96), showing an increase of 0.82 mm, less than the increase observed in the X group.

For anterior teeth in the WE group, the mean crown length at the beginning was 7.79 mm (SD = 0.78), ranging from 6.04 to 11.35 mm. By the retention phase, the mean increased to 8.18 mm (SD = 0.93), with a modest increase of 0.39 mm, similar to the anterior teeth in the X group.

In summary, on intra-group comparison, both groups showed increased clinical crown length over time ($p<0.005$).

However, on intergroup comparison, the average differences in the crown lengths in the final finding (beginning and debond duration [p= 0.881, ns] & beginning and retention [p= 0.341, ns]) did not significantly differ between the two groups (p =0.787). However, the Levene test revealed a significant difference in the variance of the mean canine length between the X and WE groups in the final finding (p = 0.007); the X group demonstrated a more pronounced increase for the canines.

Table 3: Correlation of various variables to the X/WE decision.

Significant value means a correlation to the extraction decision.

		Beginning		Debond		Retention	
Variable		R	p-value	R	p-value	R	p-value
Dental Aspects	Crown length canines	0.703	0.83	0.561	0.57	0.455	0.86
	Crown length anterior	0.881	0.46	0.739	0.73	0.626	0.93
Symphyseal Aspects	D1	0.260	0.1	0.645	0.001*, sig	0.358	0.001*, sig
	D2	0.577	0.14	0.511	0.001*, sig	0.382	0.001*, sig
	D3	0.668	0.15	0.235	0.01*, sig	0.333	0.001*, sig
	D4	0.309	0.62	0.504	0.44	0.406	1.01
Skeletal Aspects	Front face level	0.602	0.73	0.774	0.25	0.675	0.76
	Backface level	0.703	0.79	0.480	0.46	0.284	0.85
	DIV	0.881	0.27	0.431	0.26	0.455	0.55

Spearman’s correlation coefficient, level of significance set at p-value

Correlations to the therapy decision:

Table 4 presents the correlation of various variables with the decision to extract teeth (X) versus widen the dental arch (WE) in orthodontic treatment, evaluated at three stages: beginning, debonding, and retention. The Spearman's correlation coefficient (R) indicates the strength of the relationship between the variables and the decision to extract teeth. At the same time, the p-value determines the statistical significance of the correlation. A significant p-value (less than 0.05) suggests that the variable correlates meaningfully with the extraction decision.

Table 4: Regression equation model.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	7.88	0.177	44.565	0.001*, sig
Treatment therapy	-0.0133	0.204	-0.065	0.949, ns
Tooth Type	1.12	0.204	5.486	0.001*, sig

Dental Aspects:

For the crown length of canines, the correlation to extraction is relatively strong at the beginning (R = 0.703). Still, the relationship weakens over time, with R-values of 0.561 at debonding and 0.455 during retention. However, none of these correlations is statistically significant, as indicated by the high p-values (0.83, 0.57, and 0.86, respectively), meaning there is no significant relationship between canine crown length and the extraction decision at any stage.

A strong positive correlation (R = 0.881) is observed for the crown length of anterior teeth at the beginning of treatment. Still, again, this correlation diminishes over time, with R-values of 0.739 at debonding and 0.626 during retention. The p-values (0.46, 0.73, and 0.93) suggest that none of these correlations are statistically significant, indicating that anterior crown length is unreliable for predicting the extraction decision.

Symphyseal Aspects:

The variables D1, D2, D3, and D4 refer to different dimensions of the mandibular symphysis (Figure 3) For D1, there is a weak initial correlation (R = 0.260, p = 0.1), but the relationship becomes significant at debonding (R = 0.645, p = 0.001) and remains significant during retention (R = 0.358, p = 0.001). This indicates that D1 significantly correlates with the extraction decision during and after treatment, suggesting that this dimension plays an important role in the orthodontic decision-making process.

Similarly, for D2, the correlation is moderate at the beginning (R = 0.577) but becomes statistically significant at debonding (R = 0.511, p = 0.001) and retention (R = 0.382, p = 0.001). This pattern indicates that D2, like D1, is a significant predictor of the extraction decision during the later stages of treatment.

D3 follows a similar trend, with a moderate initial correlation (R = 0.668), but a significant correlation emerges at debonding (R = 0.235, p = 0.01) and remains significant at retention (R = 0.333, p = 0.001). The statistical significance suggests that D3 is also an essential factor influencing the extraction decision, particularly in the later stages of treatment.

For D4, the correlation is relatively weak and non-significant across all stages, with R-values of 0.309, 0.504, and 0.406 and p-values of 0.62, 0.44, and 1.01, respectively. This suggests that D4 is not a significant factor in the extraction decision at any stage.

DISCUSSION

Orthodontic extraction therapy is commonly used to address crowding in the mandibular arch, especially when non-extraction methods are inadequate. While it can effectively resolve crowding and achieve stable alignment, there are risks of relapse, skeletal changes, and periodontal issues. Retention strategies are crucial for maintaining stability, particularly in the anterior region where relapse is frequent. [11-13] Henceforth, the present study was conducted among 70 orthodontic patients to compare long-term outcomes of cases treated with extraction (X) to those treated without extraction (WE)

Analyzing the intra-class correlation values (ICC) of the cephalometric and plaster model measurements indicates consistent repeatability and high data reproducibility. Little's Irregularity Index was used to measure arch crowding in the gypsum models. Despite recent criticism of the Little Index as outdated and inaccurate, the obtained ICC values (above 0.99) appear to contradict the claim of inaccuracy. [14]

This study analyzed patients with moderately crowded anterior mandibles undergoing either extraction or non-extraction therapy. Standardized parameters ensured reliable results, with no significant difference in arch crowding. To ensure comparability of mean ages at retention documentation, it was essential to address the age-related increase in recession prevalence. Both groups had an average retention time of about seven years, with no significant differences noted. [15]

Extraction therapy typically requires a longer treatment duration than non-extraction methods, averaging an additional 250 days. This is due to the complexities involved in space closure after extractions. Despite the extended treatment time, both extraction (X) and non-extraction (WE) therapies resulted in only minor, clinically insignificant changes in clinical crown length during the retention phase, which were not statistically significant.

Mavreas D et al. (2008) support this, noting that extraction treatment usually lasts longer without age being a significant factor in patients with permanent dentition. For Class II division 1 malocclusion, earlier treatment may lead to longer durations. Variability in treatment duration exists within public health systems, influenced by factors like operator experience, technique, patient compliance, and initial malocclusion severity. Additionally, impacted maxillary canines tend to prolong treatment duration. [7]

Both extraction (X) and non-extraction (WE) groups showed growth in the crown length of mandibular anterior teeth and canines from initial to final assessments. Despite a reduction in clinical crown length after treatment due to potential gingivitis from fixed appliances, the outcomes were similar for both groups.

Disparities in crown lengths during debonding and retention may arise from occlusal abrasion from chewing or bruxism, particularly with fixed retainers. Since both groups were equally affected and retained for the same duration, the impact on comparison should be minimal. However, changes within one group may have occurred due to occlusal abrasion, suggesting that observed increases in crown length reflect minimal recession, as abrasion primarily reduces absolute crown length. [16]

Notably, the extraction group exhibited a higher variance in the crown length of the canines, although neither group showed additional recessions at the end of the observation period. This variation in the extraction group may be attributed to its heterogeneous sample in the cross-comparison, leading to increased variance. [1,17]

A key finding is that there is no direct link between the decision to extract teeth and the development of gingival recession. While both canines and anterior teeth showed some recession, canines were more vulnerable, particularly with excessive buccal movement. The extraction decision is not the primary factor leading to recession, indicating that other factors like tooth movement mechanics, periodontal response, and patient variables may be more significant. Research by Wennström et al. (1993), Gorbunkova A et al. (2016), and Rotundo R et al. (2010) suggests that orthodontic treatment, even without extractions, can negatively impact periodontal health, leading to attachment loss and recession. Excessive forces during treatment, especially with anterior teeth, may also cause recession. [17-19]

The study reveals that specific symphyseal aspects (D1, D2, D3) significantly influence extraction decisions during debonding and retention stages. Additionally, clinical crown lengths of front and canine teeth were similar in both extraction and non-extraction groups, suggesting that extraction is not a cause of recession. Mild mandibular crowding did not lead to recessions either, aligning with previous studies. However, evidence indicates that orthodontic treatment and retention could result in recessions, independent of treatment level. [20]

A significant finding of the study is the difference in clinical crown lengthening between canines and anterior crowns, which contradicts previous research suggesting anterior teeth are more prone to recession. The study noted that a slight inclination angle facilitates more buccal tilting of anterior teeth, suggesting extraction for significantly buccally inclined and crowded teeth. Additionally, short D1 distances supported extraction therapy. The changes in vertical facial structure were associated with recessions, with increased facial height correlating to crown extension in the canine area and anterior teeth

CONCLUSIONS

During the retention phase, there was a minor increase in the clinical crown lengths of both anterior and canine teeth. However, these changes were not statistically significant, indicating that while there may be slight adjustments in crown length post-treatment, these are not clinically relevant. While both canines and anterior teeth can undergo recession, canines seem to be more susceptible. Observations indicate that changes in vertical facial growth during treatment may be related to the development of gingival recession, suggesting a potential link between facial development and recession.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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