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Factors affecting treatment duration - a dilemma In orthodontics

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ORIGINAL ARTICLE

FACTORS AFFECTING TREATMENT DURATION – A DILEMMA IN ORTHODONTICS

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Background: One of the first concerns of new orthodontic patients, apart from the outcome, is the duration of treatment. A better understanding of orthodontic treatment duration as well as factors affecting the treatment duration is useful for efficient patient counselling and improved clinical practice. Hence, the objectives of this study are to compare the treatment durations of subjects with Class I and Class II division 1 (II/1) malocclusions, and to identify the factors affecting the treatment duration of these malocclusions. **Methods:** This was a chart review conducted in the orthodontic department of the Aga Khan University Hospital, Karachi. The study sample comprised of 120 subjects and data were recorded from their treatment records. ANOVA and Bonferroni post-hoc were performed to determine the difference in treatment durations of Class I and Class II/1 malocclusions, whereas multiple linear regression was applied to identify the factors affecting the treatment duration. A level of significance ($p \leq 0.05$) was used for the statistical tests. **Results:** A statistically significant difference was found between the treatment durations of Class I and Class II/1 non-extraction ($p=0.007$), Class I non-extraction and Class II/1 extraction ($p=0.001$), and Class I and II/1 extraction ($p=0.004$) groups. The factors significantly increasing the treatment duration included missed appointments, breakages, and lower incisor proclination. **Conclusion:** Orthodontic treatment of Class II/1 malocclusion lasts longer than that of Class I malocclusion. Prolonged treatment time is associated with missed appointments, band/bracket debonds and increased lower incisor inclination. The variance in treatment time can be explained most significantly by number of missed appointments and breakages

Keywords: Class-I malocclusion; Class-II/1 malocclusion; Treatment duration; Missed appointments; Breakages

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INTRODUCTION

An accurate judgment of treatment duration by an orthodontist is crucial for a successful practice.[1] Orthodontic literature[2,3] as well as our clinical experience suggest that one of the first concerns of new orthodontic patients, apart from the outcome, is the duration of treatment. Moreover, while treating a patient, an orthodontist faces several instances where prediction of treatment duration becomes essential. Timely completion of treatment results in greater patients' satisfaction those are less vulnerable to co-operation burn-out and increased referral of additional patients.[4–6] Additionally, better understanding of factors affecting the duration of orthodontic treatment results in efficient patient counselling, accurate estimation of treatment cost, increased cost efficiency and therefore, an improved clinical practice.[3–5]

A malocclusion can require different types of treatment depending on its severity, patient's age and his/her compliance. The various treatment modalities used to correct the malocclusion and the types of malocclusion have significant effects on the treatment duration.[6,7] Hence, for an orthodontist, it is important to recognize the prevalent malocclusions, their treatment considerations as well as their treatment durations. Several studies have been conducted to examine the frequency of different malocclusions among various populations and it was found that patients with Class I and Class II Division 1 (Class II/1) malocclusions constitute a notable proportion of population opting for an orthodontic treatment, while Class II Division 2 (Class II/2) and Class III occur less frequently.[8,9] Similar findings were observed in a local hospital based study aimed to determine the pattern of malocclusion among orthodontic patients.[10]

Although it is complicated to accurately predict the duration required to correct these prevailing malocclusions, the orthodontic treatment records offer substantial information that can be used for this purpose. Despite its clinical importance, there are few studies that have examined factors influencing the length of orthodontic treatment. Fink and Smith[11] found a significant association between treatment variables and treatment time. O'Brien *et al*[12] found that extractions in Class II/1 patients resulted in longer treatment duration. In contrast, Vig *et al*[13] found no significant treatment time difference between extraction and non-extraction cases. An unexplained variation in treatment duration among various orthodontic practices necessitates the identification of factors associated with these disparities. Therefore, the aim of this study is to offer an organized attempt to compare the treatment durations of Class I and

Class II/1 malocclusions as well as to identify the factors affecting the treatment duration of these malocclusions.

MATERIAL AND METHODS

This study is a retrospective chart review of precisely maintained patient-treatment notes in the orthodontic office. Study participants comprised a consecutive convenience sample of 120 Pakistani subjects (adolescents and young adults) with Class I and Class II/1 malocclusions, which had undergone complete orthodontic treatment in our practice with best possible outcome. Patients were excluded if they were younger than 10 or older than 30 years at the start of treatment, being retreated, treated in 2 stages, or with phase I/surgery or had missing teeth before treatment.

Data were collected from the patient treatment records including files, orthodontic casts and lateral cephalograms. Information was recorded as:

1) Patient information - age and gender
2) Cast information - overjet, overbite and occlusal relationship
3) Cephalometric information - ANB angle, palatal plane (ANS-PNS) angle to SN, i.e., SNMx, mandibular plane (Go-Gn) angle to SN i.e. SNMP, upper incisor inclination to SN i.e. UISN, and lower incisor inclination to mandibular plane (Go-Me), i.e., IMPA
4) Treatment information – start and finish dates of orthodontic treatment, type of Class II appliance (Clark twin block, bionator, Herbst appliance), number of months of Class II appliance and intermaxillary elastic wear, use of expansion appliance (yes/no), premolar extractions (yes/no), number of breakages, number of missed appointments, average time between appointments (weeks), and patient compliance (in terms of negative entry in the file).

Overjet was measured on the dental cast as the horizontal distance from incisal edge of the most proclined maxillary central incisor to the labial surface of corresponding mandibular incisor, using a straight ruler to the nearest of 0.5 mm. Similarly, overbite was measured as the vertical distance on the labial surface of mandibular incisor between its incisal edge and the pencil line marked at the point of greatest overlap. The occlusal relationship was recorded according to the Angle's classification.[14]

To collect the cephalometric information, lateral profile radiographs were taken by the method described by Siersbæk-Nielsen and Solow,[15] i.e., teeth in occlusion, standardized head posture and the mirror position. The radiographs were taken in a cephalostat (Orthoralix 9200/Ceph) with a film-to-focus distance of 134 cm and a film-to-median plane distance of 15 cm. The pre-treatment lateral cephalograms of subjects fulfilling the inclusion criteria were traced by the principal investigator and the cephalometric variables were recorded.

A bracket repositioned with an aim to correct tooth position was considered as debonded/broken and included in the total number of breakages. Any appointment cancelled and rescheduled within a week was not considered as missed appointment. All the patients included in the present study were treated by single orthodontist, using preadjusted fixed appliances with 0.022" x 0.028" bracket slot, extraoral headgear to reinforce anchorage for the maxillary teeth, and intermaxillary elastics to aid in correction of occlusal relationship. In extraction treatment, the canines were retracted using sliding mechanics with round wire, whereas the anterior teeth were retracted en masse using loop mechanics with the rectangular wire, after levelling and alignment. Deep overbites were mostly corrected with the help of reversed and accentuated curve of Spee archwires. Treatment duration was defined as the dependent variable in this study and recorded as the total time (in months) between start and finish dates of treatment. Initiation of treatment was defined as the first appointment when the functional appliance was delivered or bands were placed. Completion of treatment was considered when the best possible results were achieved and fixed appliances were removed. This excellence in finishing included obtaining an overjet of 1–3 mm, overbite of 1–4 mm, coincident midlines, Class I canine relationship, full-unit Class I or Class II molar relationship (depending on extraction pattern), correction of crossbites and rotations, and acceptable second molar occlusion. Patients who were debonded before the finishing stage (i.e., with compromised occlusion) were not included in the sample.

Intra-examiner reliability of the cast and cephalometric measurements was assessed by remeasuring the records of 15 patients, 24 hours after the initial recording. A high correlation was found between the two sets of measurements (r = 0.895 to 0.951). All statistical analyses were performed using SPSS for Windows (version 19.0 Chicago Inc. USA). Descriptive statistics such as mean and standard deviations of age and treatment duration were determined. Frequency distribution was calculated for qualitative variables like gender and factors affecting the treatment duration in malocclusion groups. ANOVA was applied to determine the difference in treatment durations of Class I and Class II/1 subjects, and extraction and non-extraction groups. Bonferroni post-hoc test was used to assess the difference amongst different strata groups. Multiple linear regression analysis was used to determine significantly related variables to the treatment duration. A level of significance ($p \leq 0.05$) was used for the statistical tests.

RESULTS

Our study sample comprised of 120 subjects with mean ages of 15 years and 6 months of females (SD±8.16 months) and 16 years and 2 months (SD±5.21 months) of

males at the beginning of treatment. The mean treatment durations of Class I non-extraction, Class I extraction, Class II non-extraction and Class II extraction groups were 36.7 months (SD±12.89 months), 41.3 months (SD±10.31 months), 48.83 months (SD±14.59 months) and 54.17 months (SD±17.38 months), respectively; and there was statistically significant difference in the treatment duration between groups (Table-1). Table-2 further elaborates the variations in treatment duration and shows a statistically significant difference between Class I and Class II non-extraction groups (mean difference -12.06 months, p=0.007), Class I non-extraction and Class II extraction groups (mean difference -17.04 months, p<0.001), as well as Class I and II extraction groups (mean difference -12.73 months, p=0.004).

The descriptive statistics of continuous variables are presented in table-3. The scatterplots showed a linear relationship of lower incisor inclination, breakages and missed appointments with the treatment duration. However, no relationship was observed between treatment duration and other quantitative variables (Annexure A-D). The Pearson correlation coefficient was used to detect the correlation of treatment duration with the independent variables showing linear relationship in the scatterplots. Table-4 shows a moderate positive correlation of treatment duration with lower incisor inclination (r = 0.40) and breakage (r = 0.49), and a strong positive correlation of treatment duration with missed appointments (r = 0.82).

The effect of independent variables on the orthodontic treatment duration was assessed by using multiple regression analysis (Table-5), and the regression model explained 85.7% of variance in the treatment duration of our subjects. The model further explained that all premolar- and upper premolar-extraction protocols increase the treatment time by 8.5 and 9.9 months, respectively, as compared to non-extraction therapy. Whereas, each degree increases in the pre-treatment lower incisor inclination, each month of functional appliance wear, each breakage and missed appointment increase the treatment duration by 0.3, 0.5, 0.4 and 1 month respectively. These independent variables were included in a stepwise linear regression analysis to provide an explanation for the variance found in treatment time. Figure-1 indicates that 30% of the variation found in treatment time could be explained by the number of missed appointments and 15.6% was contributed by breakages. Whereas, other factors including the premolar-extraction protocol, duration of functional appliance and lower incisor inclination contributed an additional of 12–14% each to the explanation of the variance in treatment duration.

Table-1: Comparison of treatment durations between groups

Study Groups	Treatment Duration (Months)		*p*-value
	Mean	SD	
Class I Non-ext (n = 25)	36.77	12.89	0.001*
Class I Ext (n = 25)	41.43	10.31	
Class II Non-ext (n = 25)	48.83	14.59	
Class II Ext (n = 25)	54.17	17.38	

One-way ANOVA, *p-value ≤ 0.05, N = 100, Non-ext = Non-extraction treatment, Ext = Extraction treatment

Table-2: Treatment time difference between groups

Study Groups	Mean Difference (Months)	*p*-value
Class I Non-ext and Class I Ext	-4.67	1.000
Class I Non-ext and Class II Non-ext	-12.06	0.007*
Class I Non-ext and Class II Ext	-17.40	0.001**
Class I Ext and Class II Non-ext	-7.4	0.260
Class I Ext and Class II Ext	-12.73	0.004*
Class II Non-ext and Class II Ext	-5.33	0.863

Post Hoc Bonferroni *p-value ≤0.05, N = 100, Non-ext = Non-extraction treatment, Ext = Extraction treatment

Table-3: Descriptive statistics for model, cephalometric and treatment variables (independent variables)

Variables	Study Groups				Total Sample Mean (SD)
	Class I Non-Ext Mean (SD)	Class-I Ext Mean (SD)	Class-II Non-Ext Mean (SD)	Class-II Ext Mean (SD)	
Age (years)	14.86 (8.30)	16.03 (3.44)	12.25 (1.71)	19.86 (5.48)	15.75 (5.94)
Overjet (mm)	3.60 (1.32)	4.77 (1.61)	8.83 (2.39)	7.90 (1.78)	6.28 (2.81)
Overbite (mm)	3.33 (1.32)	2.30 (1.39)	4.47 (1.83)	3.50 (2.01)	3.40 (1.81)
ANB Angle (°)	3.23 (1.71)	5.00 (2.45)	7.03 (2.23)	5.43 (0.89)	5.18 (2.33)
SNMx (°)	7.90 (2.68)	7.23 (2.11)	7.90 (3.10)	7.30 (3.12)	7.58 (2.76)
SNMP (°)	33.03 (4.25)	33.93 (4.35)	33.63 (5.04)	31.03 (4.46)	32.91 (4.62)
UISN (°)	106.87 (6.49)	110.87(3.54)	107.60 (7.81)	110.13 (6.49)	108.87 (6.34)
IMPA (°)	96.83 (7.01)	104.07(7.37)	103.23 (5.85)	105.70 (6.53)	102.46 (7.44)
Expansion (mon)	0.93 (3.55)	0.00	2.57 (4.60)	0.50 (1.13)	1.00 (3.08)
Functional Appliance (mon)	4.03 (7.22)	0.00	11.80 (8.87)	1.33 (3.03)	4.29 (7.43)
Non-compliance (n)	0.83 (1.26)	0.57 (1.04)	4.17 (3.06)	1.73 (2.56)	1.83 (2.56)
Breakages (n)	12.33 (11.61)	7.83 (5.11)	13.53 (9.02)	13.03 (8.72)	11.68 (9.10)
Missed Appointments (n)	8.00 (6.33)	7.20 (6.24)	12.50 (8.52)	13.13 (12.78)	10.21 (9.15)
Intermaxillary Elastic (mon)	7.83 (5.08)	14.53 (6.17)	11.33 (6.58)	15.10 (13.62)	12.20 (8.93)

N = 100, SNMx = Palatal plane angle, SNMP = Mandibular plane angle, UISN = Upper incisor inclination, IMPA = Lower incisor inclination, Mon = Months

Table-4: Correlation with treatment time

	Treatment Duration	IMPA	Breakage
IMPA	0.40*		
Breakage	0.49*	0.24*	
Missed Appointment	0.82*	0.15	0.31*

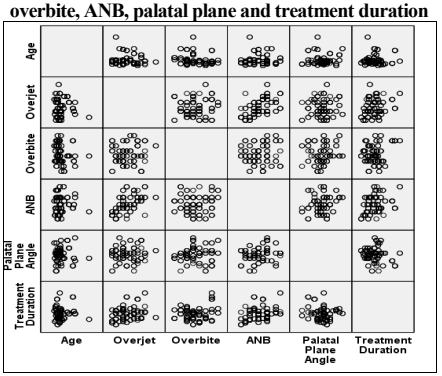
Person Correlation Coefficient, N=100, IMPA = Lower incisor inclination

Table-5: Effect of independent variables on treatment duration

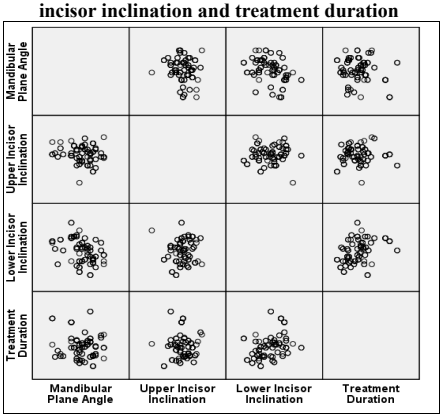
Variables	B1	Standard Error
(Constant)	-14.46	7.96
All Premolar Extraction	8.53	1.46
Upper Premolar Extraction	9.98	2.23
IMPA	0.36	0.08
Duration of Functional Appliance	0.59	0.09
Breakages	0.48	0.07
Missed Appointments	1.00	0.07

Multiple linear regression analysis, N = 100, R^2 (Coefficient of Determination) = 0.857, B1 = Unstandardized Coefficient, IMPA = Lower incisor inclination

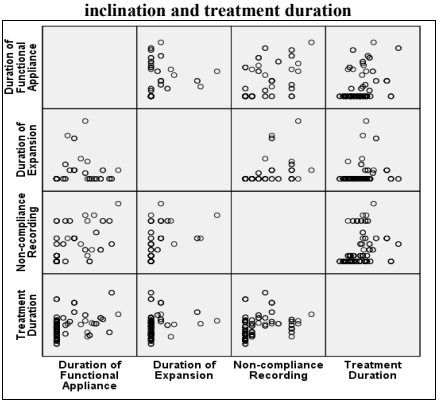
Annexure-A: Scatter plot between age, overjet, overbite, ANB, palatal plane and treatment duration



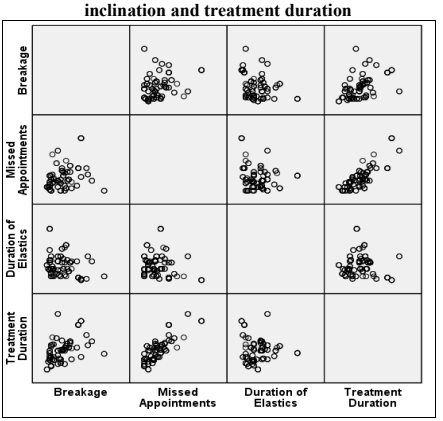
Annexure-B: Scatter plot between mandibular plane angle, upper incisor inclination, lower incisor inclination and treatment duration



Annexure-C: Scatter plot between mandibular plane angle, upper incisor inclination, lower incisor inclination and treatment duration



Annexure-D: Scatter plot between mandibular plane angle, upper incisor inclination, lower incisor inclination and treatment duration



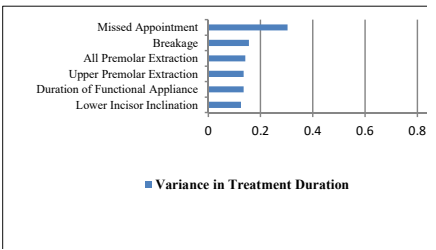


Figure-1: Factors explaining the variance in treatment duration

DISCUSSION

One of the main goals of this study was to determine the difference in the treatment durations of prevalent malocclusions, i.e., Class I and Class II/1 malocclusions. Our results clearly indicate that Class II/1 malocclusion takes, on average, 12 additional months to be corrected as compared to Class I malocclusion. A previous study by Skidmore *et al*[2] with similar objectives also showed that pre-treatment class II molar relationship significantly increases treatment duration. We further observed that the mean duration of Class I non-extraction and Class I extraction groups was 36.77±12.89 and 41.43±10.31 months, respectively. Although extraction cases took longer to be completed as compared to non-extraction, this difference was not significant. Similarly, no significant difference was observed between the mean duration of Class II non-extraction and extraction groups (48.83±14.59 and 54.17±17.38 months, respectively). However, the regression analysis revealed that extraction protocol results in an addition of 9 months on average to the total treatment time. The present study supports the findings by Vig *et al*[16] that extraction of teeth prolonged the treatment time by 5 months on average. Similarly, Alger[17] noticed that for extraction patients, treatment time averaged 4.6 months longer than for non-extraction cases and Skidmore *et al*[2] reported that extractions resulted in a further increase of 2.6 months in treatment time. Fink and Smith[11] found extraction of teeth to be one of the most substantial variables accountable for the variance in treatment duration.

After examining 120 treated cases with ideal finish, we observed that the factors correlated with the treatment time were missed appointments, breakages, and increased pre-treatment lower incisor proclination. The regression model explained that each missed appointment and breakage increase the treatment duration by 1 and 0.4 month, respectively. An increase of 0.3 month in the treatment duration is observed with a single degree rise in the pre-treatment lower incisor inclination. Furthermore, each month of functional appliance wear results in an addition of 0.5 month in the duration of orthodontic treatment. These results are consistent to previous studies reporting that increased treatment time is associated with number of replaced brackets, missed appointments, headgear, functional appliance, poor oral hygiene and premolar extraction.[3,6,11] Moreover, the current study also suggests that various factors are responsible for the variance in treatment duration such as number of missed appointments, number of breakages, non-extraction or extraction treatment, duration of functional appliance and pre-treatment incisor inclinations. Amongst all, missed appointments added considerably to the amount of explained variance.

This is in close agreement to the findings by Beckwith *et al*[3] who reported that inclusion of failed appointments in their statistical analysis added 17.6% to the amount of explained variance. Fink and Smith[11] also examined this variable and similar to the present findings, concluded that missed appointments added significantly to treatment duration. However, in their study, number of failed appointments explained only 5.2% of difference in treatment duration.

The results of the present study suggest that number of breakages significantly affects the treatment duration; however, the statistical analysis indicated only 15.6% of explanation to the treatment time variance. Similar observations were made by Shia[1] who investigated 500 treated cases to identify the factors accountable for treatment overruns and found that broken appointments, appliance breakage, and poor patient cooperation were the primary affecting treatment duration.

Our study aimed to determine the treatment duration of orthodontic patients in contemporary practice. There are various types of fixed appliances available with different prescriptions, however nowadays, majority of orthodontists worldwide and especially in Pakistan use Roth prescription. Previous literature suggests that the type of fixed appliances may also influence the treatment duration.[18] Hence, in the present study, all the subjects were exclusively treated with fixed appliance of Roth prescription (with or without functional appliance) in order to present results which are applicable to current clinical practice. Furthermore, Amditis and Smith[19] showed that difference in the slot size of fixed appliances also accounts for the variation in treatment duration. In our study, only 0.022" x 0.028" slot sized fixed appliance was used which is the most common size used in the contemporary orthodontics.

Limitations and Recommendations:

The limitations of this study were the small sample size and retrospective study design. Due to the strict inclusion criteria (particularly the standard of finishing) and limited time restraints, a study with larger sample and prospective design was not possible. Hence, future investigation in this regard would be helpful to reduce any bias. Furthermore, the sample of current study was restricted to single orthodontic practice to avoid the potential of interoperator variation. However, a multi-practice evaluation of factors affecting the treatment duration would be useful in understanding the variance in

duration among different practitioners, with careful application of results to reduce the confounders.

There is insufficient scientific evidence concerning treatment duration for some of the relatively new orthodontic modalities (such as the Invisalign technique and orthodontic mini-implants). In addition, no evidence-based information is currently available to assess treatment duration in cases in which non-conventional adjunctive methods are implemented in a view to reduce treatment time. Hence, this is an area of interest necessitating future research.

CONCLUSIONS

Based on the results of this study, the following can be concluded:

- Class II/1 treatment lasts longer than Class I treatment
- Missed appointments, number of breakages and increased pre-treatment lower incisor proclination are the factors positively correlated with the orthodontic treatment time
- Missed appointments and breakages are the most important treatment variables for the explanation of variance in treatment duration

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AUTHORS' CONTRIBUTION

SF performed data acquisition, literature search and statistical analysis. All authors were involved in the study design, manuscript preparation and review.

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