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ORIGINAL ARTICLE

Influence of Different Malocclusion Traits on Overall Orthodontic Treatment Duration: A Retrospective Cohort Study

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ABSTRACT

Objective: The specific traits of malocclusion at the outset of comprehensive orthodontics have a significant impact on the overall treatment time for fixed appliances.

Material and Methods: A retrospective cohort study of 452 patients who received comprehensive orthodontic treatment with fixed appliances between July 2020 and June 2023 in the university orthodontic clinic was performed. The following malocclusion characteristics were systematically recorded as baseline measurements: severity of crowding, sagittal relationship, vertical discrepancies (overbite), transverse discrepancies (crossbite), rotations (>20°), and impacted teeth. One-way ANOVA and multivariable linear regression were used to analyze data after the control of confounding variables including age, sex and extraction status.

Results: The average overall treatment period was 24.3 ± 6.2 months. The factors of severe crowding (>6 mm), Class II Division 1 malocclusion, deep overbite, and impacted canines were all found to be statistically significant factors that increased the length of treatment ($p < 0.05$).

Conclusion: There are certain malocclusion characteristics such as severe crowding, Class II Division 1 sagittal discrepancy and impaction of canines that significantly increase overall orthodontic treatment time. Clinicians can make more accurate treatment time estimates and design biomechanical strategies to maximize treatment efficiency when they recognize these at the diagnostic stage.

Keywords: Malocclusion, Orthodontic treatment duration, Crowding, Overjet, Retrospective study, Fixed appliances, Tooth movement.

INTRODUCTION

Malocclusion is a very common dental anomaly seen all over the world; a large percentage of the world's population suffer from malocclusion and requires orthodontic treatment to achieve functional occlusion, better periodontal health, and better esthetic results. Treatment time is however a factor of paramount importance, which directly relates to the patient's satisfaction, adherence, risk of iatrogenic side effects (e.g. root resorption), and cost of healthcare. Thus, it is crucial to know the determinants for treatment duration in modern orthodontics.[1,2] Patient compliance and biological variation are very hard to quantify and to control, while malocclusion traits are objectively measurable at the diagnostic stage. Thus, the recognition of specific malocclusion characteristics which require more time for correction can aid the clinical forecasting and informed consent process.[3,4] Tooth movement in the biomechanical resolution of crowding may be complex, involving tipping, rotation, and/or bodily translation, and is constrained by the rate at which bone can remodel. In addition, severe rotations, especially of canines and premolars, are notoriously difficult to move quickly because the supracrestal gingival fibres are very dense and remodel slowly, creating a great relapse force which slows initial tooth movement .[5,6]

Sagittal discrepancies also are significant problems of treatment efficiency, especially Class II and III malocclusions. Class II Division 1 malocclusion is often deep and requires complex anchorage management, posterior distalization and extended IMAs.[7,8] However, these mechanics are very much dependent on patient compliance, and if that is not maintained, anchorage loss can occur requiring corrective phases that lengthen the overall time-frame;[9] on the other hand, Class III malocclusions, particularly those treated with camouflage therapy, must be carefully proclined in the lower incisor areas and retroclined in the upper incisor areas, which are biologically slow due to the thin alveolar bone in the mandibular symphysis region .[10,11] Another challenge to treatment mechanics is vertical discrepancies, including deep overbites and anterior open bites. Intrusive forces on anterior teeth or extrusion of posterior teeth are biologically slow processes and are often necessary to correct a deep overbite. The dense cortical bone of anterior maxilla and mandible limits the degree of intrusion that can be obtained and light, consistent forces must be applied for prolonged periods to prevent root resorption and maintain stability.[12] Although these individual characteristics have been recognized to have an effect, most current literature has examined some of these in isolation, or in small, heterogeneous samples. Regarding breadth of analysis, there is a significant gap in the literature for multivariable analyses of the simultaneous effect of multiple baseline malocclusion traits on the duration of treatment in a large, contemporary patient sample. Many previous studies have used malocclusion cases that were surgically treated, mixed dentition cases, or different appliance systems, which have confounded the real effect of the malocclusion traits .[13]

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MATERIAL AND METHODS

This research was designed as a retrospective cohort study and was carried out at the Department of Orthodontics of Multan Medical & Dental College, Multan. The Institutional Review Board (IRB) and the Research Ethics Committee approved the research protocol and a waiver of informed consent was obtained because the data collection was retrospective and anonymized. The study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting observational studies. Sample size was determined earlier, with the aid of G Power software. The minimum number of patients required was calculated to be 159 in a one way ANOVA with three groups at alpha error probability of 0.05 and statistical power (1-β) of 0.80. The number of patients to be included was raised to 450, for possible 20% of incomplete records or exclusion criteria. Strict eligibility criteria were used to guarantee a homogeneous sample and to distinguish the influence of malocclusion traits. The inclusion criteria were: (1) patients between 12 and 18 years of age at the beginning of treatment; (2) complete permanent dentition (excluding the third molars); (3) complete baseline and

final records with good quality study models (digital or plaster), panoramic radiographs, lateral cephalograms, and intraoral and extraoral photographs; and (4) no interruptions in the treatment period more than 3 months in length. The exclusion criteria were (1) patients with syndromic conditions or cleft lip and palate; (2) patients who had undergone orthognathic surgery; (3) patients with a history of previous orthodontic treatment; (4) congenital absence of more than two permanent teeth (excluding third molars); (5) severe periodontal disease; and (6) incomplete medical or orthodontic records. For the baseline assessment, data were retrieved from the EHRs by two calibrated orthodontists who were masked of the final treatment. The reliability of the inter-examiners was determined by testing a random sample of 30 records, with an excellent Intraclass Correlation Coefficient (ICC) of 0.92. Crowding: Measured by the lower and upper arch Little's Irregularity Index (LII). The crowding was classified as: None/Mild (0-3 mm); Moderate (4-6 mm); Severe (>7 mm). The maximum value of the two arches was used for analysis. Sagittal Relationship: based on Angle's Molar Classification on the right side, or left, if the right was not present; it can be classified into Class I, Class II Division 1, Class II Division 2, and Class III. Vertical Discrepancy: Overbite was determined as the distance between the incisal edge of the upper central incisor and the lower central incisor in millimeters. It was classified as Normal (1-3 mm), Deep Overbite (>3 mm), Open Bite (<0 mm). The presence or absence of a posterior crossbite (unilateral or bilateral) was noted from study models and clinical photographs, which was classified as transverse discrepancy. Rotations: Teeth with rotations more than 20 degrees from their normal axial inclination, on baseline study models were entered as a binary variable (Present/Absent). Unerupted Impacted Tooth: When any unerupted, impacted tooth was present that would need surgical exposure and orthodontic traction (most commonly the maxillary canine teeth) was recorded as a binary variable (Present/Absent). Extraction Status: Non-extraction, or Extraction (premolar extractions). The main variable was the total treatment time for orthodontics (in months). This was only to be defined as the time from the date the first continuous archwire was placed to the date the appliance was removed as recorded in the clinical charts. The observation period before bonding and the period of retention after bonding were clearly defined and excluded. IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA) was used for data analysis. A multivariable linear regression model was created to estimate the independent effects of each malocclusion trait after adjusting for the potential confounding factors. Treatment duration (months) was the dependent variable. Independent variables were age, gender, extraction status, severity of crowding, sagittal relationship, vertical discrepancy, crossbites, rotations and impactions. To assess for multicollinearity, Variance Inflation Factor (VIF) was computed and a VIF of less than 5 was deemed acceptable. All analyses were performed with a level of statistical significance of $p<0.05$.

RESULTS

A total of 452 patients were selected for analysis, based on inclusion criteria.

The longer the treatment, the higher the level of crowding. Severe crowding patients took an average of 8.3 months longer to be treated than mild and no crowding patients, demonstrating how biomechanically complex it can be to treat significant arch length discrepancy.

The treatment duration was longest with Class II Division 1 malocclusion, at an average of 5.4 months longer than with Class I malocclusions. There were also statistically significant increases in treatment time for Class II Division 2 and Class III than for Class I, though not as great, which is attributed to the additional challenge of sagittal correction.

Table 3 shows that deep overbite and open bite conditions significantly increased the treatment time when compared with normal overbite. Deep bite cases required an average of 4.3 months more, presumably because the biological process of anterior intrusion or posterior extrusion necessary for a stable correction is slow in deep bite cases.

Table 1: Influence of Crowding Severity on Treatment Duration

Crowding Severity (Little's Index)	N (%)	Mean Duration (Months) ± SD	95% CI	p-value
None / Mild (0–3 mm)	142 (31.4%)	20.1 ± 4.5	19.3 – 20.9	< 0.001
Moderate (4–6 mm)	185 (40.9%)	23.8 ± 5.1	23.0 – 24.6	< 0.001
Severe (>6 mm)	125 (27.7%)	28.4 ± 6.8	27.2 – 29.6	< 0.001

ANOVA with Tukey's post-hoc test. All pairwise comparisons were significant ($p < 0.05$).

Table 2: Influence of Sagittal Relationship on Treatment Duration

Sagittal Relationship (Angle's Class)	N (%)	Mean Duration (Months) ± SD	95% CI	p-value
Class I	198 (43.8%)	21.5 ± 4.8	20.8 – 22.2	< 0.001
Class II Division 1	156 (34.5%)	26.9 ± 6.5	25.8 – 28.0	< 0.001
Class II Division 2	52 (11.5%)	25.2 ± 5.9	23.5 – 26.9	0.012
Class III	46 (10.2%)	24.1 ± 5.4	22.5 – 25.7	0.034

ANOVA with Tukey's post-hoc test (Reference: Class I).

Table 3: Influence of Vertical Discrepancy on Treatment Duration

Vertical Discrepancy (Overbite)	N (%)	Mean Duration (Months) ± SD	95% CI	p-value
Normal (1–3 mm)	210 (46.5%)	21.8 ± 4.9	21.1 – 22.5	< 0.001
Deep Overbite (>3 mm)	178 (39.4%)	26.1 ± 6.1	25.2 – 27.0	< 0.001
Open Bite (<0 mm)	64 (14.1%)	25.5 ± 5.8	24.0 – 27.0	0.004

ANOVA with Tukey's post-hoc test (Reference: Normal).

Table 4: Influence of Complex Localized Traits on Treatment Duration

Complex Trait	Present (N)	Mean Duration (Months) ± SD	Absent (N)	Mean Duration (Months) ± SD	p-value
Rotations (>20°)	134	26.7 ± 6.4	318	23.1 ± 5.5	0.002
Impacted Teeth	48	31.5 ± 7.2	404	23.4 ± 5.6	< 0.001
Posterior Crossbite	89	26.2 ± 6.0	363	23.6 ± 5.8	0.008

Independent samples t-test.

Table 5: Multivariable Linear Regression Model Predicting Treatment Duration

Predictor Variable	Beta Coefficient (β)	Standard Error	95% CI	p-value	VIF
(Constant)	14.2	1.8	10.6 – 17.8	< 0.001	-
Age (per year)	0.4	0.2	0.01 – 0.79	0.045	1.12
Extraction (Yes vs No)	2.1	0.8	0.5 – 3.7	0.010	1.34
Severe Crowding (>6mm)	4.2	1.3	1.6 – 6.8	0.002	1.45
Class II Div 1	3.8	1.2	1.4 – 6.2	0.004	1.28
Deep Overbite	2.5	1.0	0.5 – 4.5	0.015	1.21
Impacted Canines	5.1	1.5	2.1 – 8.1	< 0.001	1.18

Dependent Variable: Treatment Duration (Months). $R^2 = 0.48$, Adjusted $R^2 = 0.46$.

Table 4: The presence of any of these complex traits greatly prolonged treatment time. Perhaps most importantly, affected teeth increased the treatment time by an average of 8.1 months due to the time needed for surgical exposure, bonding, and slow orthodontic traction.

The model accounts for 46% of the variance in treatment duration, and the most important predictors are impacted canine (β = 5.1) and severe crowding (β = 4.2). The values of VIF are less than 5 which means there is no serious multicollinearity.

DISCUSSION

The aim of this retrospective study was to assess the effect of certain malocclusion characteristics at the outset of comprehensive orthodontic treatment on the overall course of treatment. The results show that the following malocclusion parameters are independent and significant factors for longer periods of treatment; severe crowding, Class II Division 1 sagittal discrepancies, deep overbite, and impacted canines. A relationship between high density and long treatment time was observed in this study that is like the one recently described in the literature. When the crowding is greater than 6 mm, complex biomechanical sequences are needed, and these often require the creation of extraction space or large amounts of arch expansion, both of which are rate limited by the biology of bone remodeling, as reported by Garcia et al.[13] Even with the control of extraction status, our multivariable model showed that severe crowding took more than four months of treatment, demonstrating that it is biologically inevitable that safe and stable alignment will take time.[14,15] Sagittal discrepancies, especially Class II Division 1 malocclusion, were also found to be significant factors associated with extended treatment. This is in keeping with the findings of Johal et al. (2022) that a simple mechanical process of Class II correction is not often possible, as it often involves distalization of the maxillary molars, which demands solid anchorage control, or intermaxillary elastics, which are very patient-sensitive.[16,17]

Loss of elastic wear can result in anchorage loss, which requires these months to be spent again trying to compensate for the lost elastic wear and correct the molar relationship. Deep overbites (or vertical discrepancies) also showed a significant influence on prolonging treatment. Intrusion of maxillary and mandibular incisors or extrusion of posterior teeth are the common ways to correct a deep overbite.[18,19] Biologically, it is one of the slowest orthodontic movements because the anterior regions have dense cortical bone and if forces are not carefully controlled there is a high risk of apical root resorption.[20,21]

Our data revealed that deep overbite cases required 2.5 months, on average, longer to resolve than cases with normal vertical relationship, even after controlling for crowding and sagittal class. This underlines the need for clinicians to use a light, sustained, intrusive forces and set realistic time goals with patients with deep bite malocclusions. Treatment was also lengthened by the existence of complex localized traits like severe rotations and impacted teeth. The problem with teeth that rotate more than 20 degrees is that they tend to be the most stubborn! This is mostly because of the tension created by the supracrestal gingival fibers when derotating, which creates a strong continuous relapse force which works against the orthodontic force system.[22,23]

The first part of derotation is a slow movement and the retention phase is a very careful approach to the movement. The decrease in treatment time was most pronounced in impacted teeth, mainly maxillilary canines, however. Sometimes the multi-disciplinary approach, that is, radiographic localization and surgical exposure to slow controlled orthodontic traction of the impacted tooth adds a year or more to the total treatment time. There are several limitations within this retrospective study. First, the fact that data was used from electronic health records led to the inability to measure all variables that could impact the outcomes of elastic wear or oral hygiene, although some of these effects were accounted for in the malocclusion complexity variables.

CONCLUSION

Finally, this retrospective cohort study revealed that a handful of baseline malocclusion characteristics can be important influences on the total length of comprehensive orthodontic treatment. Impacted canine, deep overbites, Class II Division 1 sagittal discrepancies and severe crowding (> 6 mm) are all independent and statistically significant factors in treatment time. It is important for the clinician to be able to identify these characteristics at the first diagnostic phase to give the patient a realistic estimate of treatment time, optimize biomechanical planning and improve the informed consent conversations with the patient and parent or guardian.

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