Factors related to Orthodontic Treatment Duration in a Graduate Orthodontics Program

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Abstract. *Introduction*: To establish the relationship between orthodontic treatment time and educational/administrative/clinical factors, in patients treated and finished, at the orthodontics clinic of a university. *Methods*: Data were obtained from clinical records, panoramic radiographs, and final dental cast from 40 treated patients (21 women and 19 men), 15.97 ± 5.79 years old. Administrative variables included number of attended appointments, number of appointments per year of treatment, total number of missed appointments, total months of treatment, number of effective months of treatment, number of residents and instructors attending to patients, and percentage of treatment planning for next appointment. Clinical variables included malocclusion complexity, finalization quality, teeth extractions, age, and number of orthodontic appliance issues/breakages. *Results*: Average ± SD treatment duration was 55.5 ± 22.2 months. In patients with dental extractions, treatment time was significantly higher (p=0.0231). A model of multiple linear regression explained 59% of variability, identifying four significant variables, two related to administration (number of missed appointments and number of instructors) and two clinical variables (number of orthodontic appliance issues/breakages and finalization quality). *Conclusion:* Significant clinical and administrative issues were detected and it was observed that excessive treatment time may deteriorate the static clinical results achieved.

Keywords: compliance, corrective orthodontics, malocclusion, linear models, observational study, time-to-treatment.

Factores relacionados con la duración del tratamiento de ortodoncia en un programa de posgrado en ortodoncia

Resumen. *Introducción*: establecer la relación entre el tiempo del tratamiento de ortodoncia y los factores educativos/administrativos/clínicos en pacientes tratados y terminados en la clínica de ortodoncia de una universidad. *Métodos*: los datos se obtuvieron a partir de registros clínicos, radiografías panorámicas y molde dental final de 40 pacientes tratados (21 mujeres y 19 hombres), 15,97 ± 5,7 años. Las variables administrativas incluyeron el número de citas cumplidas, el número de citas por año de tratamiento, el número total de citas perdidas, el total de meses de tratamiento, el número de meses efectivos de tratamiento, el número de residentes e instructores que atendieron a los pacientes y el porcentaje de planeación del tratamiento para la siguiente cita. Las variables clínicas incluyeron la complejidad de la maloclusión, la calidad de la finalización, las extracciones dentales, la edad y el número de problemas/roturas de aparatos de ortodoncia. *Resultados*: la duración media ± de del tratamiento fue de 55,5 ± 22,2 meses. En pacientes con extracciones dentales, el tiempo de tratamiento fue significativamente mayor (p = 0,0231). Un modelo de regresión lineal múltiple explicó el 59% de la variabilidad e identificó cuatro variables significativas, dos relacionadas con la administración (número de citas perdidas y número de instructores) y dos variables clínicas (número de problemas/roturas de los aparatos de ortodoncia y calidad de la finalización). *Conclusión*: se detectaron aspectos clínicos y administrativos significativos y se observó que el tiempo excesivo de tratamiento puede deteriorar los resultados clínicos estáticos alcanzados.

Palabras clave: cumplimiento, ortodoncia correctiva, maloclusión, modelos lineales, estudio observacional, tiempo de tratamiento.

Fatores relacionados à Duração do Tratamento Ortodôntico no Programa de Graduação em Ortodontia

Resumo. *Introdução*: Estabelecer a relação entre a duração do tratamento ortodôntico e os fatores educacionais/administrativos/clínicos em pacientes tratados e finalizados na clínica de ortodontia da universidade. *Métodos*: Dados foram obtidos a partir de registros clínicos, radiografias panorâmicas e modelagens dentárias finais de 40 pacientes tratados (21 mulheres e 19 homens), de 15,97 ± 5,79 anos. Variáveis administrativas incluíram número de consultas atendidas, número de consultas por ano de tratamento, número total de consultas perdidas, total de meses de tratamento, número de meses efetivos de tratamento, número de residentes e instrutores atendendo aos pacientes e percentual de planejamento de tratamento para a próxima consulta. Variáveis clínicas incluíram a complexidade da maloclusão, a qualidade da finalização, extrações dentárias, idade e número de problemas e quebras de aplicações ortodônticas. *Resultados*: A média de duração do tratamento era de 55,5 ± 22,2 meses. Em pacientes com extrações dentárias, a duração do tratamento era significativamente mais longa (p=0,0231). Um modelo de regressão linear múltipla explicou 59% da variabilidade, identificando quatro variáveis significativas, duas relacionadas à administração (número de consultas perdidas e números de instrutores) e duas variáveis clínicas (número de problemas e quebras de aplicações ortodônticas e qualidade da finalização). *Conclusão:* Questões clínicas e administrativas significativas foram detectadas e foi observado que o tempo excessivo de tratamento pode deteriorar os resultados clínicos estáticos alcançados.

Palavras-chave: conformidade, ortodontia corretiva, maloclusão, modelos lineares, estudo observacional, duração do tratamento.

Introduction

Academic training of orthodontic residents includes clinical treatment of patients affected by craniofacial and/or occlusal disorders. Usually, this training gives priority to clinical, biomechanical, and physiological issues well documented in current literature [1]. However, the educational/administrative aspects of the clinical service at a university graduate program are not so well documented and there is less evidence about their influence upon duration of treatment and clinical outcomes.

For patients, treatment success depends on the achievement of an esthetically pleasant and balanced smile, after the shortest time of treatment [2]. In 1999, Beckwith [3] stated that patients tend to be more satisfied when they receive information about duration of treatment and the kind of treatment they will receive. Some authors such as Parrish [2] have reported degree of complexity and initial dental discrepancy index to be some factors that increase treatment duration. Also, other authors have found that presence of impacted teeth [4], surgical need, patient's compliance and provision of care in a public or private health service can also affect treatment time [5, 6]. A very long treatment must be avoided as it may increase costs as well as the patient's risk to suffer effects such as root resorption [7], white spot lesions [8] and periodontal disease, among others [9].

The aim of this study was to identify and describe clinical and administrative variables affecting duration of standard orthodontic treatments as performed at the orthodontics clinics of the Universidad de Antioquia during 2012-2013 and to determine its relationship with some clinical and educational/administrative factors.

Materials and methods

This observational cross-sectional study included 40 consecutive patients, non-randomly selected, according to the following inclusion criteria: Patients who finished the active treatment during 2010-2012, treated by fixed bimaxillary orthodontics and initiating the retentive phase. The exclusion criteria were patients not willing to participate in the study, and/or patients requiring other prosthetic/periodontal treatments or surgical procedures.

Educational/Administrative variables

Number of attended appointments, number of appointments per year of treatment, number of missed appointments, number of months of treatment (including months of active treatment plus months without register in the medical record), number of effective months of treatment, number of instructors and residents providing care and percentage of treatment planning for next appointment were included. These data were taken from the medical records of patients by two independent investigators, and repeated after a two-week interval to check agreement. When any inconsistency was detected, criteria were standardized and repeated until attaining a 100% agreement.

Clinical variables

Malocclusion severity, finalization quality, teeth extractions, age of patient at the beginning of treatment and number of orthodontic appliance issues/breakages were included. Malocclusion severity was expressed by an index developed at the Universidad de Antioquia, based upon the number of space planes involved in the initial malocclusion [10]. This "grade of compromise" was categorized according to the number of planes involved as *low compromise* if two planes were involved, *medium compromise* when three planes were involved, and *high compromise* when four or five planes were involved. Kind of treatment (with or without dental extractions), number of orthodontic appliance issues/breakages, and initial age of patient were taken from the clinical records. Finalization quality was provided by a static analysis of the final cast models and panoramic radiographs, using the criteria of Grading System for Dental Casts and Panoramic Radiographs formerly known as Objective Grading System (OGS), standardized by the American Board of Orthodontics (ABO) and described by Casko et al. and Cameron [11, 12].

Following the protocol previously described [10], final models were converted to digital images by IMAX (Imágenes Maxilofaciales S.A.) in Medellín, Colombia. Following previous reports of different authors [13–15], model casts were digitalized. Evaluators were calibrated for intra- and inter-examiner error, obtaining an Intraclass Correlation Coefficient of 0.97 for quantitative values and a kappa coefficient of 0.98 for qualitative

appraisals. The OGS value was classified as *excellent* (less than 20 points), *acceptable* (20 to 30 points) and *less than acceptable* (more than 30 points). This final appraisal is called Clustered OGS.

Ethical issues

In writing the article, we followed the STROBE checklist [16]. During the study the 2008 WMA Declaration of Helsinki was taken into account and followed as well as the regulations of Resolution 08430 of 1993 from the Republic of Colombia. The Ethics Committee of the School of Dentistry, Universidad de Antioquia, which reviews, approves and monitors studies involving human subjects, approved the study protocol by Minutes No. 07-2011 of May 11, 2011. Patients signed an informed consent to participate in the study.

Statistical analysis

Data were processed using the statistics program Stata 12 (Stata Corp 2011. Stata Statistical Software: Release 12. College Station, TX: Stata Corp LP). Qualitative variables were described by frequency and percentage; quantitative variables were expressed as average and standard deviation. Pearson or Spearman coefficients for correlation and association between variables was calculated by Chi square. For two group comparisons, the t test was used and, for more than two group comparisons, ANOVA was used. A multivariate analysis was performed by multiple correlation and regression calculations. Significance level was $p = 0.05$.

Results

From a population of 99 patients who finished orthodontic treatment during 2010-2012, 46 were excluded due to the need for other therapeutic interventions, 9 refused to participate, and 4 had inadequate diagnostic data. The final sample of 40 patients (21 women and 19 men) had an average ± standard deviation initial age of 15.97 ± 5.79. Summary statistics for the final sample are shown in Table 1.

Table 1. Summary statistics for independent and dependent variables

Variable	Category	Frequency	Relative Frequency %
Gender	Male Female	19 21	47.5 52.5
Complexity (space planes)	1 2 3 4 5	3 5 11 17 3	7.69 12.82 28.21 43.59 7.69
Grade of compromise	Low Medium High	8 11 21	20 27.5 52.5
Clustered OGS	Excellent Acceptable Less than acceptable	4 16 20	10 40 50
Extractions	Yes No	17 23	42,5 57,5
Variable	**Mean**	**SD**	**Rank**
Age (years)	15.97	5.79	10-35
Treatment duration (months)	55.5	22.2	13-121
Effective treatment time (months)	43.35	14.74	13-93
Number of attended appointments	37.3	11.39	10-66
Treatment duration in extraction group (months)	63.6	19.57	39-121
Treatment duration in non- extraction group (months)	49.5	22.53	13-105
Number of appointments 1st year	10.47	2.81	4-17
2nd year	7.4	2.44	1-13
3rd year	6.91	2.25	0-11
4th year	6.17	1.81	2-10
5th year	4.54	2.59	0-9
6th year	3.71	2.23	0-8
Number of instructors	2∞	-	1-5
Number of residents	3∞	-	1-6
% of treatment planning	39.83	16.4	13.9-66.7

(viene)

Number of appliance is-sues/ breakages	6.9	7.6	0-40
Missed appoint-ments	4.05	3.76	0-14
∞ Median			

Source: Compiled by the authors

Duration of treatment for patients with dental extraction of two or more premolar teeth had an average of five additional appointments, corresponding to about 14 additional months of treatment (Figure 1). This difference in duration of treatment was significant (Chi squared test, p=0.0231)
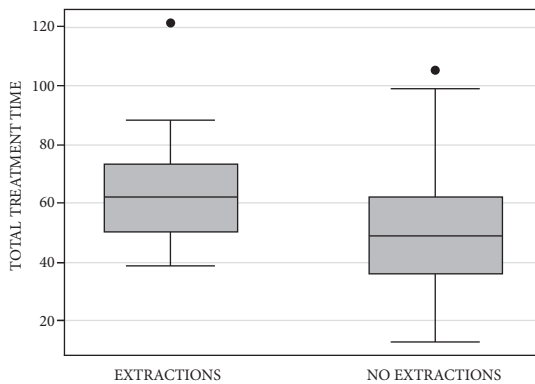

Figure 1. Treatment duration for extraction and non-extraction groups
Source: Compiled by the authors

Variables showing a p value < 0.3 for linear regression versus duration of treatment were included in the regression model. Covariant variables were not included in the model and nominal categories were included as dummy factors. The teeth extractions variable was not significant for the final model (p = 0.340) (Table 2).

Regarding quantitative variables and treatment duration, no correlation was found except for kind of treatment (Table 3).

For any missed appointment treatment duration increased 2.67 months; for every orthodontic appliance issue/breakage treatment time increased 1.14 months; and for each different instructor it increased 6.6 months. The clustered OGS according to the regression model is inversely related to length of treatment (for acceptable OGS = 27.68 months and for less than acceptable OGS = 29.09 months). The final multiple regression model explained 59% of variance in duration of treatment (R^2=0.587) (Table 4). Treatment duration would be almost 25 months if there were no missed appointments, no repairs were required, and only 1 instructor supervised the treatment.

Discussion

Duration of orthodontic treatment is one of the factors that patients consider as an obstacle to decide on the treatment and consequently they perceive it as part of the service quality [17]. Authors such as Dickens [18] report differences in duration of orthodontic treatment between university

Table 2. Quantitative variables and relation to treatment time

Variable	Correlation	p value	R^2	p value regression
Treatment duration/ Appointments attended	0.8015	-	0.642	0.0000[a]
Treatment duration/ Number of residents providing care	0.8516	-	0.725	0.0000[a]
Treatment duration/ ogs score	0.1648	-	0.027	0.3094
Treatment duration/ Effective months of treatment	0.8384	-	0.702	0.0000[a]
Treatment duration/ Missed appointments	0.5534	0.0002*	0.335	0.0001*
Treatment duration/ Repairs	0.3373	0.0333*	0.090	0.0598
Treatment duration/ Age at start	-0.1156	0.4893	0.009	0.5688
Treatment duration/ Number of instructors	0.4274	0.0060*	0.154	0.0122*
[a] Covariants, not included in the regression regardless of p < 0.05 * p<0.05				

Source: Compiled by the authors

Table 3. Categorical variables analysis

Variable	p value bivariate	R²	p value regression
Treatment duration and kind of treatment (extraction/non-extraction)	0.0231*	0.100	0.0462*
Treatment duration/Clustered ogs	0.1545	0.096	0.1545
Treatment duration/Malocclusion complexity level	0.3765	0.113	0.3765
Treatment duration/Grade of compromise	0.3915	0.049	0.3915
* p < 0.05			

Source: Compiled by the authors

Table 4. Multiple regression model for treatment duration

Treatment duration (months)	Coefficient	p value	Confidence interval 95% R²
Number of missed appointments	2.67	0.000*	1.27 - 4.07
Number of repairs	1.14	0.003*	0.41 - 1.87
Number of instructors	6.60	0.043*	0.23 - 12.97
Clustered OGS (Dummy) 2 (Acceptable) 3 (Less than acceptable)	 27.68 29.09	 0.005* 0.003*	 9.05 - 46.32 10.27 - 47.91
Constant	24.95		0.587
* p < 0.05			

Source: Compiled by the authors

institutions and private practice. The results of the present study are limited by the small number of available patients, which is significantly lower than the number attended to in American universities, as reported by Vu in Indiana [19] and Brown et al. [20] in Detroit, and in private practice [21], but it is higher compared to reports from other Colombian universities [22].

Duration of orthodontic treatment in this study (55.5 ± 22.2 months) is longer than international average standards. The literature allows flexible results, in a range from 18 to 36 months considering design of the study, complexity of initial malocclusion [23], orthodontic techniques [24], dental extractions [25] and even size of the bracket slot [26]. Ochi [5] provides a treatment duration range (9-125 months) similar to that obtained in the present study, but the mean and standard deviation were lower (26 ± 5.4). The difference might be related to the fact that, in the present study, only 37.5 % of patients finished the treatment in the usual range of time reported in the literature and two patients had been treated for more than 100 months.

The obtained multivariate regression model was able to explain 59% of variance, similar to the models of Oliveria [27], and Turbil et al. [23], which explained 43.75% and 41% of variability, respectively. Other clinical and administrative factors remain to be identified in further studies in order to explain 41% of variance not covered by the present model. It was considered that age of patients at the beginning of treatment increases duration of treatment when it is initiated early or in the presence of temporary teeth [5, 23]. However, in the present study, age was not significantly related to duration of treatment, in agreement with the reports of Schafer [28] and Vig et al. [29].

Regarding influence of the degree of treatment complexity, Vu et al. [19] and Parrish et al. [2] found that the discrepancy index is a factor that increases duration of treatment, but Saxe [30] and the present study did not find significant correlation. Notice that degree of treatment complexity in the present study was established using the patient's medical record. Other ways to calculate discrepancy such as PAR [31] could be more reliable as the index used in this study has not been fully validated.

Dental extractions had a significant effect as treatment was longer with extractions than without extractions (p = 0.0231), in agreement with the reports of Skidmore et al. [6] and Alford et al. [24], showing that extraction of premolar teeth increased length of treatment by seven months. Janson [32] reported that extraction of four instead of two teeth increased length of treatment by five months. There is a consensus about this topic because Mavreas et al. in a systematic review [33] concluded that dental extractions increase duration of treatment. Size of the bracket slot was not a variable in this study because all the patients were treated with 0.018-inch slot brackets.

Experience of the clinician and number of instructors attending to the patient are also factors considered relevant for treatment duration. MacGuinnes et al. [34] found that the number of residents treating the same patient increases time of treatment. In the present study, although correlation between number of residents and length of treatment was high, it was not considered in the multivariate analysis model due to covariance. On the other hand, the number of instructors in the clinics was included in the multiple regression model and was relevant to explain 15% of variance (p = 0.0122). This finding suggests that when a resident transfers the patient to another student, under the guidance of the same instructor, duration of treatment will not be affected as it might occur when another instructor introduces changes that modify the course of treatment. Vu et al. [19] and Oliveira [27] reported a significant association between duration of treatment and orthodontic appliance issues/breakages (p = 0.0001). The present multiple regression model estimates that reparative activities may increase time of treatment by 1.14 months (CI: 0.42-1.87) for each episode (p = 0.003).

The more important variable to explain variance in duration of treatment in the regression model was the number of missed appointments (p = 0.0001) (R^2 = 33.5%). Each missed appointment increased treatment by 2.67 months (ic: 1.27 - 4.1). This result is similar to that of Melo et al. [27]. Therefore, patient's compliance is an aspect that must be improved in the graduate university service, and it is further complicated by the lack of continuity due to university vacation periods. Suggested actions to stimulate patients' attendance are appointment reminder calls and a plan to fully

control patients at the beginning and end of each academic term. Perhaps university vacation periods compromise patient treatment and should be changed. In addition, a longer treatment time could affect the sense of belonging of trainers and students, leading to increased treatment time.

Unexpectedly, the impact of finalization quality (clustered OGs) was found to be negatively correlated to time of treatment, suggesting that increasing the length of treatment does not necessarily ensure better finalization. Pinskaya [35] concluded that an extended treatment actually reduces outcome quality, perhaps because compliance and patient motivation tend to reduce over a prolonged time. However, it also suggests that a longer treatment is expected in cases that are not going well, resulting in poor treatment quality.

The present study is limited first by the number of patients, insufficient to detect small differences in some factors, and the wide confidence intervals observed in the estimates reported in Table 4 are probably due to the small sample size, in addition to the lack of a random sample of patients and the short time for sampling. However, the study reveals factors that suggest important ways to reduce duration of treatment for the benefit of both patients and clinical students learning in a university setting. Then, it is evident that patients with extractions, missed appointments, complex malocclusions and orthodontic breakages need a special follow-up guide and a loyalty program with hygiene appointments and a special schedule in order to reduce time of treatment.

Conclusions

- The multiple regression model developed to explain variability in duration of orthodontic treatments explains 59% of this variance.
- Duration of orthodontic treatments is significantly higher (p = 0.0231) when treatment includes dental extractions, compared to treatment without extractions.
- Number of missed appointments, orthodontic appliance issues/breakages, instructors and clustered OGs are the main factors related to duration of orthodontic treatment.
- According to the regression model, the time constant for duration of treatment was 24.95 months. This time is increased by 2.67 months

for every missed appointment, 1.14 months for every orthodontic appliance issue/breakage, and 6.6 months for each instructor.

- Duration of treatment is negatively correlated to clustered ogs.

Declaration

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