An evaluation of factors affecting duration of orthodontic treatment

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One of the first questions asked by new orthodontic patients is: How long will I need to wear my braces? A multitude of factors have the potential to influence the answer to this question. The purpose of this retrospective study was to identify some of the primary factors that influence orthodontic treatment duration. Few studies have attempted to evaluate these factors. Data were gathered from 140 consecutively completed, comprehensive treatment patient records in five orthodontic offices. Thirty-one variables related to patient characteristics, diagnostic factors, modality of treatment, and patient cooperation were evaluated. Average treatment time was 28.6 months with a range of 23.4 to 33.4 months among the five offices. Nearly half (46.9%) of the variation in treatment duration was explained by a five-step multiple regression analysis. Included in the regression equation were the number of missed appointments, the number of replaced brackets and bands, the number of treatment phases, the number of negative chart entries regarding oral hygiene, and the prescription of headgear wear during treatment. An additional 6.7% of the variance was explained by variation among the five offices. Six of the 31 variables examined made a statistically significant ($\alpha = .01$) contribution to the explanation of variation in treatment time. The quality of the finished cases and the appropriateness of the original diagnosis and treatment plan were not evaluated. Developing an objective assessment to evaluate these areas may be important for increasing our understanding of treatment time variation. (Am J Orthod Dentofacial Orthop 1999;115:439-47)

Shia[1] asserted that success in orthodontic practice is tied to accurate prediction of treatment duration. His statement makes sense for several reasons: patients want to know how long orthodontic treatment will take before treatment begins; patients whose treatment was completed "on time" may be more satisfied and more likely to refer additional patients; timely completion of treatment allows more accurate prediction of the number of treatment visits, and therefore a more accurate prediction of overhead costs. This provides valuable information for determining fees.

Despite the somewhat obvious importance of being able to accurately predict orthodontic treatment duration, surprisingly little research has been conducted to evaluate those factors that influence treatment time. Shia[1] listed 18 factors that increased treatment time in his own practice, but he failed to provide any of his data. Grewe and Hermanson[2] found no relationship between treatment duration and three indexes of malocclusion severity[3,4] or a subjective assessment of patient cooperation. Vig et al[5] found that 5 of 9 variables examined (the number of treatment phases, one or both arches treated, pretreatment molar relationship, the age at start of treatment, and extraction versus nonextraction status) had a statistically significant association with treatment duration; however, they were able to explain only one third of the variance. Alger[6] found that he treated his nonextraction patients 4.6 months faster than those on which he extracted teeth for orthodontic treatment. Fink and Smith[7] conducted the most extensive study to date of factors that may influence the length of orthodontic treatment. A statistically significant association was found with 4 of the 18 variables examined (extraction of premolars, number of broken appointments, pretreatment mandibular plane angle, and pretreatment ANB angle). They indicated that 50% of the variation in treatment duration could be explained by a 5-step multiple regression analysis; however, examination of their reported results indicated that they actually explained

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Table I. List of variables by type

Variable type	*Trait evaluated*	*Previously investigated*
Patient factors	Sex of patient	Y
	Adult versus child status	N
	Child age at start	Y
Patient diagnostic characteristics	Angle molar	Y
	Extraction status	Y
	Interincisal distance	N
	Saddle angle	N
	Articular angle	N
	Gonial angle	N
	Sum angle	N
Treatment modality	Orthodontic office	N
	Single vs multiple phases	Y
	Metal vs ceramic brackets	N
	Nickel-titanium wires used	N*
	Months nickel-titanium used	N
	% of time in nickel-titanium	N
	Elastics wear prescribed	N
	Time elastics prescribed	N
	Headgear wear prescribed	Y
	Time headgear prescribed	N
Patient compliance	Missed appointments	Y
	Months of missed appointments	N
	Number of brackets rebonded	N
	Number of bands recemented	N
	Sum of replaced brackets and bands	N
	Elastic wear negative chart entry	N
	% negative elastic wear entries	N
	Headgear wear negative chart entry	N
	% negative headgear wear entries	N
	Negative oral hygiene chart entry	N
	% negative oral hygiene entries to total treatment time	N

*Jones et al[23] found initial incisor alignment with NiTi and stainless steel wires to be statistically equivalent.

only 24.9% of the variance in treatment time. Their final R was 0.499, and thus R^2 was 0.249.[8,9]

The sensible notion that duration of treatment should increase as the difficulty of the case increases has not been well substantiated. For example, Fink and Smith[7] found that a larger ANB angle corresponded with increased treatment time; however, they were surprised to find that patients with a larger mandibular plane angle tended to have a shorter treatment time. Bjork[10] and Jarabak and Fizzell[11] have described the relationship among the saddle angle, articular angle, and the gonial angle on the lateral cephalometric radiograph. As an alternative to the ANB and mandibular plane angles, these angles are useful in describing the degree of prognathism as well as the direction of growth.[10,11] Their possible association with treatment duration has not been evaluated.

Vig et al[5] found no significant association between treatment-induced change in overbite or overjet and treatment duration. Even though the magnitude of the overbite and overjet may not individually influence treatment duration to a significant extent, it is possible that the overbite and overjet combination could affect the time necessary to treat a patient. This possible combined effect has not been examined previously.

The purpose of this retrospective study was to identify and quantify factors that affect orthodontic treatment duration. An attempt was made to confirm previous findings as well as to ascertain the possible contribution to length of treatment by a number of variables that have not been previously investigated. A total of 31 variables classified by logical association into the following four categories were examined: patient factors, diagnostic characteristics, treatment modality factors, and patient compliance. Table I lists the variables included by category.

MATERIAL AND METHODS

Pretreatment lateral cephalometric radiographs, pretreatment diagnosis, treatment plans, and all treatment progress notes were examined for 140 of the most recently and consecutively completed patients in five orthodontic offices. Twenty-eight patient records were examined from each office. All were considered to be "normal" appliance removals with comprehensive orthodontic treatment completed.

Four of the five practitioners were in the Kansas City metropolitan area, and the fifth orthodontist practices in Denver, Colo. Four of the five were diplomates of the American Board of Orthodontists. All five orthodontists use preadjusted, preangulated, and pretorqued appliances. Two practitioners use appliances with an 0.018 inch slot; two use an 0.022 inch slot; and the remaining practitioner uses an 0.018 inch slot in the upper arch and an 0.022 inch slot in the lower arch.

Intrarater reliability of the cephalometric measurements was tested by remeasuring the records from office one 1 month after the initial visit. A very high correlation was found between all repeated measurements (r = 0.955 to 0.989).

Probability values of $\alpha < .01$ were considered to be statistically significant. Two variables, molar classification and office number, were redefined in dummy variable form for analysis because each reflected three or more categories of classification. Those independent variables exhibiting a statistically significant Pearson r correlation with treatment months, the dependent variable, were selected for further examina-

Table II. Summary of categorical variables

	Office 1		Office 2		Office 3		Office 4		Office 5		Total	
Trait	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Females	82.1	23	53.6	15	75.0	21	60.7	17	50.0	14	64.3	90
Males	17.9	5	46.4	13	25.0	7	39.3	11	50.0	14	35.7	50
Adults	14.3	4	25.0	7	0.0	0	3.6	1	14.3	4	11.4	16
Children	85.7	24	75.0	21	100.0	28	96.4	27	85.7	24	88.6	124
Molar class												
I	39.3	11	25.0	7	25.0	7	32.1	9	53.6	15	35.0	49
II	46.4	13	60.7	17	71.4	20	67.9	19	32.1	9	55.7	78
III	14.3	4	14.3	4	3.6	1	0.0	0	14.3	4	9.3	13
Extraction	28.6	8	10.7	3	32.1	9	28.6	8	21.4	6	24.3	34
Nonextraction	71.4	20	89.3	25	67.9	19	71.4	20	78.6	22	75.7	106
Single phase	75.0	21	89.3	25	100.0	28	92.9	26	82.1	23	87.9	123
Multiple phases*	25.0	7	10.7	3	0.0	0	7.1	2	17.9	5	12.1	17
Metal	100.0	28	67.9	19	100.0	28	96.4	27	96.4	27	92.1	129
Ceramic	0.0	0	32.1	9	0.0	0	3.6	1	3.6	1	7.9	11
Ni-Ti Wires												
Used	100.0	28	32.1	9	3.6	1	100.0	28	3.6	1	47.9	67
Not used	0.0	0	67.9	19	96.4	27	0.0	0	96.4	27	52.1	73
Elastics	82.1	23	85.7	24	96.4	27	100.0	28	57.1	16	84.3	118
No elastics	17.9	5	14.3	4	3.6	1	0.0	0	42.9	12	15.7	22
Headgear	17.9	5	32.1	9	50.0	14	3.6	1	10.7	3	22.9	32
No headgear	82.1	23	67.9	19	50.0	14	96.4	27	89.3	25	77.1	108

*Nearly all were treated in two-phases. A few in this category were treated in three phases.
Ni-Ti, Nickel-titanium.

tion. Partial correlation coefficients with the dependent variable were then determined for each of these variables, controlling for the influence of the other remaining variables in each case. Those variables with a statistically significant partial correlation with treatment time were then selected for further study in a stepwise regression analysis. Adjusted R^2 values were used instead of R^2 values. This was done to provide a better estimate of the population R^2 and to increase the generalizability of the results of the regression analysis. To determine the contribution of the orthodontic office to the explanation of the residual variance in treatment duration, this variable was added to the regression equation after evaluation of those included in the stepwise analysis.[8,9]

RESULTS

Table II presents a summary of all categorical variables, separately for each office and for the total sample. Table III presents means and standard deviations for continuous variables measured in each patient record. Table IV presents Pearson r values for the correlation between treatment months and 29 of the 31 variables in the study. The one way analyses of variance (ANOVA) that were conducted on treatment time for molar classification and office indicated that between office differences had a statistically significant association with treatment time. Molar classification did not affect treatment time to a statistically significant degree ($P > .01$).

The 12 independent variables that resulted in a significant correlation with treatment time were subjected to a partial correlation analysis. Because the sum of replaced brackets and bands is a simple linear function of the number of rebonded brackets and recemented bands, the partial correlation analysis for both rebonded brackets and recemented bands necessarily had to exclude the sum of replaced brackets and bands as a controlled factor. Similarly, the partial correlation analysis for the sum of replaced brackets and bands could not control for either rebonded brackets or recemented bands.[8,9]

Both the time elastics wear was prescribed and the number of negative chart entries regarding elastic wear exhibited a statistically significant ($P < .01$) correlation with treatment time (Table IV). Because only 118 of the 140 patients in the sample were asked to wear elastics, only those 118 patients could be included in the initial analysis of partial correlations controlling for the influence of the 11 other variables. However, neither the time elastic wear was prescribed ($P > .01$) nor number of negative entries regarding elastic wear ($P > .01$) exhibited a statistically significant ($P < .01$) partial correlation with treatment time with the overlapping influence of the other variables controlled. This meant that the two

Table III. Mean values for variables measured on each patient by office

Variables	*Office* 1	2	3	4	5	*Total*
Treatment months	30.8	23.4	33.4	29.5	25.8	28.6
Child age (years)	12.7	12.3	12.2	11.8	12.1	12.2
Months in nickel-titanium wires	9.3	1.1	0.1	11.5	4.0	5.6
% Nickel-titanium	33.0%	5.4%	0.3%	39.0%	15.4%	19.9%
Interincisal (mm)	5.8	5.8	6.3	6.5	4.4	5.8
Saddle angle	122.3°	121.1°	126.3°	124.0°	121.6°	123.0°
Articular angle	145.4°	145.2°	140.7°	141.3°	144.8°	145.3°
Gonial angle	129.6°	128.2°	127.7°	130.8°	129.8°	128.3°
Sum angle	397.3°	394.5°	394.6°	396.1°	396.3°	395.7°
Missed appointments	2.7	1.6	3.6	2.0	2.1	2.4
Months missed	1.5	1.3	1.6	1.0	2.2	1.5
Rebonded brackets	3.6	4.4	4.9	7.9	4.8	5.1
Recemented bands	4.4	1.4	1.8	2.5	1.9	2.4
Sum brackets/bands	7.9	5.8	6.8	10.3	6.8	7.5
Months of elastics	8.4	6.5	15.1	10.9	9.2	10.3
Elastics-negative chart entries	1.4	0.5	0.7	0.6	0.2	0.7
Months of headgear	16.8	8.4	10.8	17.0	12.7	11.4
Headgear-negative chart entries	0.7	2.4	0.9	0.0	0.3	1.0
OH-negative entries	0.8	0.9	4.0	1.8	3.4	2.2
% negative OH entries	2.7%	3.8%	11.5%	6.2%	12.9%	7.4%

Table IV. Correlations with treatment time

Variable	*Pearson correlation "r" Value*	*P value*
Male versus female	–0.005	NS
Adult versus child	0.277	.001
Child age	–0.172	NS
Extraction vs nonextraction	–0.065	NS
Interincisal distance	0.126	NS
Saddle angle	0.138	NS
Articular angle	–0.221	.009
Gonial angle	0.134	NS
Sum angle	0.012	NS
Single versus multiple phases	0.369	.000
Metal versus ceramic brackets	–0.185	NS
Nickel-titanium wires	–0.050	NS
Months in nickel-titanium wires	0.119	NS
% of time nickel-titanium used	–0.107	NS
Elastics wear prescribed	–0.199	NS
Time elastics wear prescribed	0.387	.000
Headgear wear prescribed	–0.242	.004
Time headgear wear prescribed	0.296	NS
Missed appointments	0.427	.000
Months of missed appointments	0.252	.003
Number of brackets rebonded	0.222	.008
Number of bands recemented	0.419	.000
Sum replaced brackets and bands	0.386	.000
Elastic wear negative entries	0.299	.001
% negative elastic wear entries	0.123	NS
Headgear wear negative entries	0.158	NS
% negative headgear wear entries	0.050	NS
Negative oral hygiene entries	0.240	.004
% negative oral hygiene entries	0.070	NS

NS, Not statistically significant ($P > .01$)

variables related to elastic wear could be excluded from further analysis.

A second evaluation of partial correlation coefficients controlling for the other variables was conducted with the remaining 10 variables. The results are presented in Table V. Because the remaining variables were applicable to all patients, all 140 records were used in the analysis. The number of treatment phases, missed appointments, recemented bands, sum of replaced brackets and bands, and negative chart entries related to oral hygiene a exhibited a statistically significant partial correlation with treatment time ($P < .001$). Headgear wear had a near statistically significant ($P = .014$) partial correlation with treatment time.

The five remaining variables were included in a stepwise regression analysis to provide an explanation for the variance found in treatment time as well as to generate an estimate of orthodontic treatment duration. As mentioned earlier, a functional relationship exists between the number of recemented bands and the sum of replaced brackets and bands. Because of its slightly larger partial correlation with treatment time (0.3772 versus 0.3746), a decision was made to use the sum of replaced brackets and bands in the regression analysis rather than the number of recemented bands. Whether or not headgear was prescribed was included as an independent variable in the stepwise regression analysis because of its near statistically significant ($P = .014$) partial correlation with treatment time.

Table VI summarizes the results of the stepwise regression analysis and the resulting regression equation. The multiple R^2 value adjusted for sample size indicated that 46.9% of the variation found in treatment time could be explained by the five-step regression analysis. At 17.6%, missed appointments was the first to enter the equation and contributed the greatest amount to the explanation of variance in treatment duration. The sum of replaced brackets and bands entered next and contributed 13.0% more; the number of treatment phases explained an additional 8.1% of the variance in the dependent variable. Negative oral hygiene entries and headgear wear then contributed an additional 5.6% and 2.6%, respectively.

The resulting regression equation estimated that each missed appointment added 1.09 months to treatment time. Similarly, each replaced bracket and band resulted in about 2 weeks longer in appliances. Treating patients in more than one phase added nearly 8 months to treatment. Poor oral hygiene was associated with an increase of 0.67 months per chart entry, and 3.66 months was added if headgear wear was prescribed during treatment.

Table V. Partial correlation coefficients controlling for other variables significantly associated with treatment time (n = 140 patient records)

Variable	*Partial correlation with treatment time*	*P value*
Adult versus child	0.0744	.398
Articular angle	–0.0977	.267
Number of treatment phases	0.3261	*.000
Missed appointments	0.3925	*.000
Months of missed appointments	–0.0851	.334
Rebonded brackets	0.1508	.084
Recemented bands	0.3746	*.000
Sum of replaced brackets/bands	0.3772	*.000
Headgear wear prescribed	0.2147	.014
Oral hygiene negative chart entries	0.3005	*.000

*$P < .001$

To evaluate the contribution that between office variability could make in explaining a portion of the residual variance in treatment time after the stepwise regression analysis, offices as a block of dummy variables was added to the existing set of five independent variables in the regression equation. Adding the block of orthodontic offices to the regression analysis increased the amount of explained variance by 6.7% to 53.6% (Table VII).

DISCUSSION

To the limited extent that they may be compared, the patients in this study appear to be similar in general to national averages as reported by Gottlieb et al.[12-15] Few studies are available with which to compare these results. For many of the variables, an association with duration of orthodontic treatment has not been previously investigated.

More than half (53.6%) of the orthodontic treatment time variance was explained using 6 of the original 31 variables. Fink and Smith[7] and Vig et al[5] were able to explain 24.9% and 33.0%, respectively, of the variance in treatment duration found in their patient populations. Their investigations examined fewer variables than the present study, and neither study specifically examined the possible contribution of three of the six explanatory variables from the present study (replaced brackets and bands, the level of oral hygiene, and orthodontic office).

The findings in the present investigation support the observations made by Shia.[1] After examining 500 consecutively treated cases, he listed the primary causes for treatment overruns in his private practice. Poor patient cooperation, broken appointments, and appliance breakage were the top three items on his list. Three of the top four main contributors to the explana-

Table VI. Stepwise regression results*

Variable	*Equation coefficient*	*Multiple R*	*Multiple R^2*	*Adjusted multiple R^2*	*P value*
(Constant)	18.65	NA	NA	NA	.000
Missed appointments	1.09	0.427	0.182	0.176	.000
Sum of replaced brackets/ bands	0.46	0.562	0.316	0.306	.000
Treatment phases	7.93	0.633	0.400	0.387	.000
Negative oral hygiene entries	0.67	0.678	0.459	0.443	.000
Headgear prescribed	3.66	0.698	0.488	0.469	.007

*Regression equation: Estimated treatment months = 18.65 + (1.09 * missed appointments) + (0.46 * sum of replaced brackets and bands) + (7.93 * treatment phases) + (0.67 * negative oral hygiene chart entries) – (3.66 * 1 if headgear was prescribed or 2 if headgear was not prescribed)

TABLE VII. Multiple regression analysis stages

	Multiple R	*Multiple R^2*	*Adjusted multiple R^2*
Variables included in stepwise regression analysis	0.698	0.488	0.469
Missed appointments			
Sum replaced brackets/bands			
Number of treatment phases			
Negative oral hygiene entries			
Headgear prescribed			
Office variable added as a block	0.753	0.566	0.536
Office 1			
Office 2			
Office 3			
Office 4			
Office 5			

tion of treatment duration in the present study fall into these three categories (missed appointments, sum of replaced brackets and bands, and negative oral hygiene chart entries).

The most important variable measured in this study to explain differences among patients in treatment duration was the number of appointments missed during treatment. The results of the multiple regression analysis indicated this variable explained 17.6% of the treatment time variance. Each failed appointment was associated with a little over 1 month additional estimated time in appliances. Fink and Smith[7] also examined broken appointments during treatment. Similar to the present findings, their analysis found that failed appointments added significantly to treatment duration. However, in their study, 0.8 months of treatment was added per broken appointment, and inclusion of this variable in their statistical analysis added only 5.2% to the amount of explained variance.

The sum of brackets and bands replaced during treatment was the second largest contributor in the explanation of treatment time variance. It is important to note that nearly all of the influence of this variable is associated with the number of recemented bands rather than the number of rebonded brackets. The partial correlation coefficient with treatment time for the sum of replaced brackets and bands was only slightly larger than the coefficient for recemented bands (Table V). The partial correlation of rebonded brackets alone with treatment time was not statistically significant.

Bands and brackets that were repositioned during treatment were counted along with those that had come loose. This complicates the interpretation of the association found with treatment time. The number of appliances that come loose during treatment is likely to be associated with patient cooperation in avoiding certain foods or activities during treatment, but it may also be related to the bonding material and band cement used to secure the appliances. Other factors, such as doctor skill and preference as well as delegation of appliance placement to office staff, may affect the number of brackets and bands that are repositioned during treatment. Observations made within the offices indicated that many more bands and brackets were dislodged than were repositioned; however, including repositioned appliances with replaced appliances may have inflated the observed relationship with treatment time. Previous studies have not examined these variables. Further investigation is needed to distinguish the relative associations of replaced bands and brackets and repositioned appliances with treatment time.

The number of treatment phases contributed an additional 8.1% to the amount of explained variation in the treatment time. Patients treated in two or more phases wore appliances nearly 8 months longer than those treated in a single phase. In the Vig et al[5] study, adding treatment phases increased treatment time by

13.5 months per additional phase; however, they included the lag time between treatment phases in their calculations of treatment duration that would have inflated the observed association between multiple phases and active treatment time.

Poor oral hygiene apparently has a direct relationship with treatment duration. Each progress note entry regarding less than "good" oral hygiene was associated with an additional two thirds of a month in estimated treatment time. Patients with good oral hygiene may be more likely to cooperate with other aspects of treatment.[16-18] Though less likely, it is also possible that orthodontic tooth movement may be more efficient when there is less gingival inflammation. These are target areas for further research.

If headgear was prescribed during treatment, the estimated time in appliances was 3.66 months longer than if no headgear was worn. Headgear wear contributed only an additional 2.6% to the amount of explained variance, but its contribution in the stepwise analysis was statistically significant ($P = .007$). This is important because the partial correlation coefficient for headgear wear was not quite statistically significant ($P = .014$, $\alpha = .01$).

Unlike missed appointments, replaced brackets and bands, and oral hygiene that are related to patient cooperation, prescribing headgear wear during treatment is a result of other factors. The decision to prescribe headgear during treatment is related to the difficulty of treatment. The treatment mechanics used by the practitioner is also a key to the use of headgear. This is evidenced by the range noted in the use of headgear among the five practices (Table II).

The decision to treat in single or multiple phases is also quite likely to be related to practitioner preference. No attempt has been made in this study to evaluate the efficacy of treating patients in single versus multiple phases. Treating selected patients in two or more phases is often done with the expectation of improving the overall result; yet, it is still of value for the practitioner to recognize that multiple phase treatment is likely to increase treatment time.

Previous investigations[5,7] have speculated that much of the unexplained variance in treatment duration could be attributed to between office differences, but the results of this study do not support their claim (Table VII). Incorporating the five offices as a block in the multiple regression analysis added only an additional 6.7% to the amount of explained variance in treatment time. Observations made during visits to each of the offices indicated that they were as different as they were alike. These observations are supported by the ranges noted for descriptive statistics in Tables II and III. It may be speculated that a larger and random sample of offices from across the country would find greater between office differences that would explain a larger portion of the treatment duration variance. Still it seems unlikely that between office differences could account for the half of the variance in treatment time that remains unexplained.

The influence of extraction versus nonextraction treatment on the length of treatment remains controversial. The present study supported the findings by Vig et al[5] that extracting teeth for orthodontic treatment does not significantly influence the duration of treatment. At 29.2 months, the mean treatment time for extraction patients in the present study was 1.4 months longer than for those who did not have teeth extracted. This difference was not statistically significant. Fink and Smith[7] found extraction of teeth for orthodontic treatment to be the most significant of their 18 variables in the explanation of treatment time variation. Their analysis concluded that 0.94 months of treatment was added per extracted premolar. Alger[6] observed that for patients from whom he extracted teeth, treatment time averaged 4.6 months longer than for his nonextraction cases. Vaden and Kiser[19] reported that nonextraction treatment generally took 2 months less than extraction treatment among their 3600 private practice patients treated from 1963 to 1993. In all of these investigations, treatment time for patients treated with an extraction modality averaged at least 1 month longer than their nonextraction counterparts; however, the difference was not always statistically significant.

Limitations and Future Investigation

The small number of patients who fell into certain categories, such as those who wore ceramic brackets, limited the predictive ability of examining these variables. Similarly, a sample with a larger number of adults would be able to confirm or deny the influence of adult versus child status on treatment time. Adults in the present investigation were treated in less time than nonadults; however, there were insufficient adults included to ascribe statistical significance to this observation. Dyer et al[20] found adult and adolescent treatment times to be equivalent.

The chronologic age of child and adolescent patients did not demonstrate a significant association with orthodontic treatment duration in this or the Fink and Smith[7] study. Vig et al[5] found that patient age made a minor but statistically significant contribution to their explanation of treatment time variance. Gianelly[21] contends that 90% of patients would best be treated in a single treatment phase beginning in the late mixed-dentition stage of dental development. Because a patient's dental age can vary from their chronologic age,[22] the stage of dental development at the start of treatment may prove to have a direct effect on treatment duration even though chronologic age does not seem to influence treatment time. This is an area for future research.

The possibility of an association between the slot-size of the appliance used and the duration of orthodontic treatment was not specifically evaluated in the present investigation; however, it was noted that the two offices with the shortest average treatment time were the two that used an 0.018 inch slot appliance. This may be coincidence. A study that included patients from a larger number of offices would be able to investigate the possible influence of slot size on orthodontic treatment duration.

Many other variables could have been examined that have the potential to influence orthodontic treatment duration. This study examined the largest collection of variables and patient records that have been reported to date; however, an investigation that included a more extensive set of independent variables likely would explain a greater portion of the variance in orthodontic treatment duration. In this regard, the investigations conducted thus far have not supported the sensible notion that increased treatment difficulty increases treatment time. The proper variables for assessing treatment difficulty may not yet have been identified.

A significant portion of the variation in treatment duration remained unexplained in this investigation. No attempt was made to analyze either the appropriateness of the initial diagnosis and treatment plan or the quality of the finished result. Shia[1] reported that altering the treatment midapproach was a significant cause of treatment overruns in his practice. He referred to situations when nonextraction or nonsurgical treatment was initiated and the treatment plan had to be changed during treatment. An objective analysis for evaluating the appropriateness of the initial diagnosis would be beneficial in explaining variation in treatment time resulting from changes in the approach midtreatment. Such an analysis should include predicted cooperation as a factor to aid in the extraction decision for borderline cases.

An objective assessment for measuring the quality of finish would also potentially increase the amount of treatment time variation that can be explained. Studies conducted thus far have all made the assumption that patients are treated to the same end point. This is highly unlikely. Developing such objective analyses for the diagnosis, treatment plan, and finished result will be very difficult because of the diverse nature of the orthodontic profession.

CONCLUSIONS

On the basis of the results of this study of 140 patient records from five orthodontic practices, the following conclusions may be drawn:

1. Over half of the variation found in orthodontic treatment duration could be explained by six variables; three related primarily to patient cooperation, two related to treatment modality, as well as among office differences.
2. Missed appointments, loose brackets and bands, and poor oral hygiene are all patient cooperation factors that contributed significantly to increase treatment time.
3. Patients treated in more than one phase spent significantly more time in active treatment.
4. Prescribing headgear wear during orthodontic treatment was also associated with longer treatment time.
5. Between office differences contributed a minor but statistically significant role in the explanation of variation in treatment duration.
6. This area of orthodontic research is still in its infancy. Additional studies are needed to more fully investigate the causes for variation in orthodontic treatment duration as well as to validate outcomes from this study. As the influence of Managed Care continues to grow in orthodontics, profit margins will likely fall. Accurate prediction of treatment duration will become increasingly important for success in orthodontics.

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