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Original Article

Effectiveness and duration of two-arch fixed appliance treatment

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The aims of this study were to determine the effectiveness and duration of single-phase two-arch fixed appliance treatment and to evaluate factors that may influence these two variables. Data were collected from 177 consecutively completed cases at the Orthodontic Department, Government Dental Clinic, Singapore, during a three-month period. Pre-treatment and post-treatment models were assessed using the Peer Assessment Rating (PAR) index. The result showed that two-arch fixed appliance treatment reduced the malocclusions on average by 77.80 per cent over a period of 25 months. Multiple regression techniques revealed that 22 per cent of the variability in treatment effectiveness could be explained by the pre-treatment PAR score, the age at the start of treatment, the frequency of office visits and whether or not the treatment involved extractions. The variation in treatment duration was due to the frequency of office visits, the pre-treatment PAR score and whether or not the treatment involved extractions or headgear.

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Introduction

The effectiveness and efficiency of orthodontic intervention is an issue that is receiving more attention recently from patients and third-party financiers now that tools for measuring these parameters have been shown to be useful and valid.

Many studies have investigated the effectiveness of orthodontic treatment by determining the amount of dento-occlusal changes following orthodontic treatment.[1–7] Some of these studies have attempted to identify the factors that have an influence on the treatment success.[8,9]

In recent years, the Peer Assessment Rating (PAR) Index[10] has been widely used as a measure of dento-occlusal changes. Scores are assigned to the various occlusal traits that make up a malocclusion, and the sum of these scores has been shown to be a valid and reliable measure of malocclusion severity and perceived treatment difficulty.[11,12] This index can also be used as an outcome measure of treatment effectiveness by assessing the difference in scores between the pre-treatment and post-treatment study models.

The duration of orthodontic treatment is a process variable that is of interest to care providers as well as patients. To the provider, it is a measure of the efficiency of treatment and the amount of chairside treatment time, while to the patients, it represents the degree of inconvenience and the amount of time away from school or employment. Few studies have investigated the treatment duration of fixed appliance treatment or the factors that affect it.[13–15]

The aims of this study were to:

1. Evaluate the treatment effectiveness of single-phase two-arch fixed appliance treatment using the Peer Assessment Rating Index.

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Table I. Treatment duration and percentage PAR reduction (means with standard deviations in parentheses)

	No. of cases	Treatment duration in months	Pretreatment PAR score	Post-treatment PAR score	Percentage PAR reduction
Total sample	177	24.9 (9.3)	30.24 (10.88)	5.92 (4.78)	77.80 (19.59)
Age group					
< 18	145	25.2 (9.2)	30.04 (10.85)	5.53 (4.82)	79.32 (17.96)
≥18	32	23.5 (9.7)	31.13 (11.16)	7.69 (4.23) *	70.95 (24.91) *
Gender					
Female	122	24.8 (8.9)	30.68 (11.06)	5.92 (5.06)	78.17 (20.08)
Male	55	25.1 (10.3)	29.25 (10.51)	5.93 (4.14)	77.00 (18.59)
Extraction pattern					
Non-extraction	27	20.0 (7.5)	21.56 (9.76)	3.78 (3.02)	78.84 (25.03)
Extraction	150	25.8 (9.3) *	31.80 (10.35) †	6.31 (4.94) *	77.62 (20.13)
Headgear					
Yes	15	32.2 (11.3)	35.33 (11.15)	4.80 (3.65)	85.99 (9.31)
No	162	24.2 (8.8) *	29.77 (10.77)	6.02 (4.94)	77.05 (20.12)

*$p < 0.05$
†$p < 0.001$

2. Determine the treatment duration of two-arch fixed appliance treatment.

3. Identify the factors that may influence treatment effectiveness and treatment duration.

Materials and methods

Data were obtained from 177 patients who received treatment in the Orthodontic Department of the Government Dental Clinic in Singapore. All the patients were treated in a single phase with two-arch pre-adjusted Edgewise appliances with 0.022 inch slots, and were consecutively debanded between March and May in 1997. No cases were treated with orthognathic surgery. The majority of the patients were Chinese. Pretreatment and post-treatment records comprising study models and treatment notes were available for all patients.

The following data were recorded from the patients' treatment records: age at start of treatment, gender, number of office visits to complete treatment, treatment duration in months, and whether or not headgear was used. The frequency of office visits was derived as a ratio of the treatment duration over the number of office visits.

All pre-treatment and post-treatment study models were assessed using the PAR index and the percentage PAR reduction as a measure of treatment effectiveness. All models were assessed by a single calibrated examiner (C.M.T.). To assess intra-examiner reliability, 10 per cent of the sample were selected at random and re-examined four weeks after the first examination, without reference to the original results.

Data analysis

The data were analysed using SPSS for Windows. Basic descriptive statistics were generated from the data available. To test for significance between means, the Mann–Whitney U-Test was used. Stepwise multiple linear regression was used to analyse the association between the independent variables listed above and the dependent variables of treatment duration and percentage PAR reduction. Intra-examiner agreement for the PAR score measurement was evaluated by the intra-class correlation coefficient.[16] The analysis revealed excellent reliability (r = 0.98).

Results

Effectiveness of treatment (Table I)

The mean pre-treatment and post-treatment PAR scores were 30.24 and 5.92, respectively, giving a mean percentage PAR reduction of 77.80 per cent. There was no significant difference in treatment effectiveness between genders and whether or not

Table II. Stepwise multiple regression analysis with percentage PAR reduction as the dependent variable

A. Step	R	R^2	R^2 change	Sign F
1. Pretreatment PAR score	0.37	0.14	0.14	0.000
2. Age at start of treatment	0.41	0.17	0.03	0.000
3. Extraction/non-extraction	0.44	0.20	0.03	0.000
4. Frequency of office visits	0.46	0.22	0.02	0.000

B. Predictor variables in equation	Regression coefficient	Beta coefficient	Significance
Pre-treatment PAR score	0.83	0.46	0.000
Age at start of treatment	-10.50	-0.21	0.003
Extraction/non-extraction	-8.87	-0.16	0.024
Frequency of office visits	-14.06	-0.14	0.035
Constant	77.56		

Table III. Stepwise multiple regression analysis with treatment duration as the dependent variable

A. Step	R	R^2	R^2 change	Sign F
1. Frequency of office visits	0.64	0.40	0.40	0.000
2. Pre-treatment PAR score	0.68	0.46	0.06	0.000
3. Extraction/non-extraction	0.69	0.48	0.02	0.000
4. Headgear	0.70	0.49	0.01	0.000

B. Predictor variables in equation	Regression coefficient	Beta coefficient	Significance
Frequency of office visits	25.93	0.58	0.000
Pre-treatment PAR score	0.16	0.18	0.002
Extraction/non-extraction	3.72	0.14	0.015
Headgear	3.87	0.12	0.042
Constant	-11.66		

the treatment required extraction or the use of headgear. However, treatment was more effective for patients who started treatment before 18 years of age ($p < 0.05$).

Treatment duration (Table I)

The mean treatment duration for single-phase two-arch fixed appliance treatment was 25 months (Table I). The use of headgear as part of the treatment resulted in significant increase in treatment duration ($p < 0.05$). With extraction the treatment duration was similarly increased significantly ($p < 0.05$).

Variables influencing treatment effectiveness (Table II)

The regression analysis as measured by the percentage PAR reduction ($R^2 = 0.14$) revealed that the pre-treatment PAR score had the most significant effect on treatment effectiveness. Age at the start of treatment, whether or not the treatment involved extraction and the frequency of office visits explained another 8 per cent of the variability in treatment effectiveness. The derived equation for the prediction of percentage PAR reduction was as follows:

Percentage PAR reduction = 77.56 + 0.83 (pre-treatment PAR score) -10.50 (age at start of treatment) -8.87 (extraction/non-extraction) -14.06 (frequency of office visits)

where age at start of treatment was coded 0 for age below 18 years and 1 for age 18 years and above, and extraction/non-extraction was coded 0 for non-extraction and 1 for extraction. This equation accounted for only 22 per cent of the variation in percentage PAR reduction. It was of note that no other independent variables entered the equation.

Variables influencing treatment duration (Table III)

The frequency of office visits explained 40 per cent of the variability in treatment duration (R^2 = 0.40), while the pre-treatment PAR score, the involvement of extraction and the use of headgear added another 9 per cent explanation to the variability. The derived equation for the prediction of treatment duration was as follows:

Treatment duration (months) = -11.66 + 25.93 (frequency of visits) + 0.16 (pre-treatment PAR score) + 3.72 (non-extraction/extraction) + 3.87 (headgear)

where the use of headgear was coded 0 for no headgear and 1 for the use of headgear in treatment. This equation accounted for 49 per cent of the variation in treatment duration.

Discussion

The mean percentage PAR reduction of 77.80 per cent represents a high standard of treatment and is similar to that reported in previous studies. In Norway, specialist practitioners were found to achieve a 78 per cent reduction in the PAR score with fixed appliances.[6] Similarly, O'Brien *et al.*[7] found a 75.5 per cent reduction in PAR scores when two-arch fixed appliance therapy was performed in seventeen hospitals in England and Wales. The high standard of treatment reported in these studies may in part be explained by the fact that the patients were treated using upper and lower fixed appliances, which had been found to be the most efficient and effective treatment modality in Orthodontics.[5,6,9] In studies evaluating the treatment effectiveness of removable appliances, the percentage PAR reduction achieved was considerably lower.[17,18]

The pre-treatment PAR score has been shown to be a good approximation of malocclusion severity and perceived treatment difficulty.[11,12] In this sample, the mean pre-treatment PAR score was 30.24. In comparison, the mean pre-treatment score of the sample treated by the Norwegian specialist orthodontists was 23.8,[6] whereas that of the hospital orthodontic service in England and Wales was 28.8.[7] The relatively higher score for the present sample is an indication of the greater severity of the malocclusions treated in the Singapore region from which the sample was taken.

Stepwise multiple regression revealed that the pre-treatment PAR score was the most significant predictor of percentage PAR reduction amongst the independent variables. This finding suggests that the more severe the initial malocclusion, the greater the amount of favourable dento-occlusal changes achieved. Conversely, treatment of a mild malocclusion would result in a smaller percentage PAR reduction. This finding supports other studies that have found the pre-treatment malocclusion severity to be a good predictor of percentage PAR reduction.[8,19]

Age was the second best predictor of percentage PAR reduction. The regression equation showed that treatment effectiveness was reduced in adult patients above 18 years of age. This is in contrast to the findings by Robb *et al.,*[20] which revealed no difference in treatment effectiveness between adults and adolescents. The possible reason for a reduced percentage PAR reduction in this study may be that in some of the adult patients, treatment was limited to pre-restorative corrections. Premature termination of treatment may also be dictated by adult patients who, in general, exert a greater autonomy in treatment decisions and progress.

The regression model showed that the extraction of teeth as part of the treatment reduced the percentage PAR reduction. It was also noted that patients whose treatment involved extractions had a more severe initial malocclusion, as indicated by the pre-treatment PAR score (Table I), but the quality of the final occlusal result, as indicated by the post-treatment PAR score (Table I), was not as good as those cases treated without extraction. This finding could be explained by the clinicians' willingness to accept less than ideal occlusal results for those cases that were severe initially. The relatively poorer occlusal finish in extraction cases resulted in a reduced percentage PAR reduction, which was, however, not statistically significant compared with non-extraction cases (Table I).

Treatment duration showed great variation even though the sample for this study was restricted to single-phase two-arch treatment. There are few studies to which the present result can be compared, due to considerable variation in definitions

of treatment duration, as well as the treatment methods used in different studies. The present finding, which used only studies on fixed appliance treatment, is similar to the mean treatment duration of 2.1 years reported by Richmond and Andrews,[6] who used a sample treated by Norwegian specialist orthodontists. The present finding is, however, shorter than the mean of 31 months reported by Vig *et al.*[13] but marginally longer than those reported by Fink and Smith[14] and Kelly and Springate,[21] which were 23.1 months and 22.0 months, respectively. In a recent study[15] comparing the duration of orthodontic treatment with 0.018 inch and 0.022 inch slot Edgewise brackets, the mean treatment duration with 0.022 inch slot brackets was 21.7 months, which was lower than that found in this study.

The regression analysis revealed that the frequency of office visits explained 40 per cent of the variability in treatment duration (Table III). The frequency of office visits is determined by the orthodontist and usually ranges from four to six weeks. When a patient fails appointments repeatedly, the average frequency of office visits throughout the whole treatment period is increased. This would in turn lead to an increase in treatment duration, as revealed by the regression analysis. It is also likely that a patient who fails appointments repeatedly exhibits other forms of non-compliance that could compromise treatment effectiveness, such as failure to achieve adequate headgear and elastic wear and frequent appliance breakage. Poor patient compliance is a real problem in Orthodontics and its effects on the effectiveness and duration of treatment are not unexpected.

Other variables in this study that contributed to increased treatment duration were increased severity of the malocclusion as indicated by the pre-treatment PAR score, the involvement of extractions and the use of headgear. On average, extraction cases took an extra 3.72 months to complete compared with non-extraction cases. This finding is similar to that reported by O'Brien *et al.*[8] and Fink and Smith.[14] Similarly, cases that required the use of headgear took, on average, 3.87 months longer to complete.

The regression models in this investigation could explain only part of the variability in treatment effectiveness and duration. This was particularly evident for percentage PAR reduction in which only 22 per cent of the variability could be explained by the model. This would suggest that other factors that were not included in the study had a significant influence on these two dependent variables. The likely factors that could explain, at least in part, the residual variation, are the individual differences in the operators' competence and efficiency, as well as the biological responses of patients.

In this study, the assessment of treatment effectiveness was limited to the use of the PAR index. Although important, improvement in dento-occlusal relationships is not the only measure of treatment effectiveness. Changes in facial profile and improvement in facial aesthetics are other measures of the effectiveness of treatment. The Chinese population, in general, has a bimaxillary protrusive profile with increased dental and alveolar protrusion and protrusive upper and lower lips.[22,23] Frequently, patients with bimaxillary protrusion are treated with extraction of four premolars and although orthodontic treatment results in a marked improvement in tooth angulation and facial aesthetics, the PAR reduction can be low.

Summary and conclusions

This study evaluated the effectiveness and duration of single-phase two-arch fixed appliance treatment for a sample of 177 consecutively completed cases. Multiple regression techniques were used to analyse the associations between selected variables and the dependent variables of percentage PAR reduction and treatment duration. On the basis of the results of this study, the following conclusions may be drawn:

1. Using the PAR index, single-phase two-arch fixed appliance treatment reduced the malocclusions on average by 77.80 per cent over a period of 25 months.

2. Twenty-two per cent of the variability in percentage PAR reduction could be explained by the pre-treatment PAR score, the age at the start of treatment, the frequency of office visits and whether the treatment involved extractions.

3. Almost half of the variation in treatment duration was explained by the frequency of office visits, the pre-treatment PAR score and whether or not the treatment involved extractions or headgear.

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