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The influence of operator changes on orthodontic treatment duration and outcomes

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ABSTRACT

Aim: Orthodontic treatment duration is variable and associated with many factors Very few studies looks at operator changes influencing treatment duration and outcome. This study aims to evaluate the influence of operator changes on treatment time and quality. **Methodology**: This is a 4-year cross-sectional retrospective study of preadjusted Edgewise two-arch appliance cases treated by single/ multiple operators and finished/debonded by the author. 60 single-operator (Group 1) and 82 multiple-operator (Group 2) cases were selected and the Peer Assessment Rating (PAR) Index was used to measure treatment outcome. **Results**: Group 1 (2.31 years, SD.86) had statistically significantly shorter treatment time than Group 2 (3.25 years, SD1.23). Mean % reduction in PAR scores was high (88.7%), although single operators (92%) showed a slightly higher (p=.04) reduction than multiple-operator cases (86.2%). Post-treatment PAR score was slightly higher in Group 2 (4.6, SD5.4) compared with Group 1 (2.6, SD2.9). There was no significant difference in post-treatment PAR scores with operator changes from within and outside the clinic although there was difference in treatment duration (p=.0001). Possible predictors of treatment duration included number of failed/changed appointments, extractions and pre-treatment PAR. Multiple linear regression model showed significant association of treatment time with failed/changed appointments (p=.0001) and number of operators (p=.0001) although this contributed to 57.5% of possible factors (r=.762) **Conclusion:** Change of operator contributes to increased treatment time by 11.3 months. Although standard of treatment was high in both groups there was slightly better outcomes in single operators. The reduction in PAR score can be predicted more accurately in single operators.

INTRODUCTION

Literature review of orthodontic treatment duration and a previous related unpublished study by the author seem to show that patients who were treated by multiple changes of operators (orthodontists) had longer treatment duration than those treated by a single operator from start to finish.[1,2] Orthodontic treatment in routine cases typically takes about two to three years for completion and patients may be treated by different orthodontists in the same or different clinics during the course of the treatment.[3] In public specialist clinics, change of operators is inevitable and patients often are relegated to unsupervised dental officers in the interim while waiting for treatment to be taken over by another orthodontist. With easy availability and accessibility of orthodontists in local government clinics, patients often request for transfer to another clinic during the course of the treatment due to change in school or home. Delay in continuity of treatment due to these changes may prolong treatment time.[1,2]

It was also perceived that treatment outcomes may be compromised in some cases with change of operators due to change in treatment plans and complications in malocclusion management with the ‘break’ in continuity of care.[4,5] The Peer Assessment Rating (PAR) Index was developed in the United Kingdom to assess orthodontic treatment outcome and standard. It assigns numerical values to various occlusal traits that make up a malocclusion and the overall weighted sum of these represents the degree of departure of the occlusion from the ideal occlusion.[6] The higher the score, the more severe the malocclusion and where there is excellent occlusion, the total score is zero or near zero. This Index has been validated and has been used extensively in many countries to assess the standard of treatment outcome.[6,7,8,9]

The PAR Index has been adopted by the Ministry of Health Malaysia in recent years as a quality assurance and key performance indicator for orthodontists in government-run clinics.[10,11] However, the criteria used were for single operators only and excluded all cases carried out by multiple operators or transfer cases. Thus there was no reported or published local data on the standard of treatment in the multiple operator cases and very few published reports in the literature.[1]
The aims of this study were:

1. To investigate the average treatment time and PAR score reduction
2. To compare the treatment duration and treatment outcomes in orthodontic cases between single and multiple-operators
3. To determine any predictors of treatment duration

MATERIALS AND METHODS

Ethical approval was granted by the MOH National Institute of Health (NMRR-13-1447-17298) in 2014 for this study and local research approval was granted by the Selangor State Deputy Director of Oral

Health. This was a cross-sectional study of all completed treatment records over a four-year period (2011-2013) in the Klang government Orthodontic clinic which was finished and debonded by the author. Inclusion criteria was cases treated with upper and lower pre-adjusted Edgewise fixed appliance (.022x.028" slot) and exclusion criteria were single-arch treatment, removable or functional appliance cases, orthognathic surgery, cleft and craniofacial syndrome and early terminated cases.[1,12,13]

Sample size and power of study was calculated using Altman's nomogram.[17] If sample size was calculated using clinically meaningful difference in treatment time of at least 6 months between the study groups to achieve an 80% power with an α of .05, the estimated number of patients required was 30. This was based on the study by McGuiness and McDonald[1] using their mean treatment times and standard deviation for single and multiple operator groups. However, this sample size was inadequate for comparison of treatment outcome using the PAR Index. McGuiness and McDonald[1] showed mean reduction in PAR score was about 70% and 80% in the two groups but there was no statistical significant difference when the average PAR score at the end of treatment was compared. This means that there was no statistical significant difference in quality of treatment outcomes although there was a difference of 10% in mean reduction in PAR score. A greater than 70% mean reduction in PAR score was considered high standard of treatment.[6,7] Previous annual reports (unpublished) of PAR score reduction by government orthodontists in the Ministry of Health Malaysia for single operators showed a range from 80-92%.

Thus, to satisfy sample size for both treatment time and treatment outcome, we based our sample size calculation for the number of patients necessary to achieve an 80% power with an α of .05 on a clinically meaningful difference in PAR Index mean score reduction of 20% between the study groups[1]. The calculation showed that we needed to recruit about 140 patients in the total sample (70 in each group). In total there were 142 cases which satisfied the criteria; 60 cases had their treatment started and completed by the author (single operator, Group 1) and 82 cases had their treatment started by another operator(s) but whose treatment was taken over and finished by the author (multiple operators, Group 2).

Data was obtained from complete patient treatment records, radiographs and study models and the case was excluded where there were incomplete records. Data collected included patient demographics, malocclusion type, routine case/ impacted teeth for alignment/ dental anomalies, extraction pattern, number of changed/broken appointments, length of treatment time, number of operators and change of operators within/ outside the clinic. Changed/broken appointments included appointments which were changed by the patient or clinic and failed attendance. Total treatment time was the duration between bonding (initial attachment) of the fixed appliance and debonding (removal) at completion of treatment. A change of operators was defined as treatment started by an orthodontist and which is transferred and taken over by another orthodontist in the same or different clinic. This did not include operators such as dental officers who may have attended to the patient in the interim.

PAR Index measurements and interpretation[6]

The PAR Index was used in this study as a measure of the standard of treatment outcome. The degree of improvement is expressed quantitatively as 'percentage improvement' and scores at pre-treatment and post-treatment indicates the severity of the malocclusion at start and quality at finish. The qualitative improvement is expressed as 'greatly improved', 'improved' 'worse/no different' by interpretation of the pre and post-treatment scores from the PAR nomogram. 'Greatly improved' indicates an improvement of 22 or more points, 'improved' indicates an improvement equal to or greater than 30% change and 'worse/no improvement' reflects scores of less than 30% improvement.

This Index looks at five components of the occlusion, namely; the upper and lower anterior segments, right and left buccal occlusion, overjet, overbite and centerline. The individual scores for each component are multiplied by the assigned weightings and then summed to establish the overall total score. Weightings derived for the 5 components are (x1) for upper and lower anterior segment alignment, (x1) for right and left buccal occlusion, (x6) for overjet, (x2) for overbite and (x4) for centerline. PAR Index scores were measured with a PAR transparent ruler on pre and post-treatment study models. A total score of zero indicates perfect alignment and high scores indicate severity of deviation from the ideal. The percentage change from pre to post-treatment PAR scores indicates the percentage improvement. PAR scores were obtained with the use of the transparent PAR ruler by the author. [6,7]

The qualitative degree of improvement as expressed by the nomogram is not directly correlated with percentage improvement because the nomogram takes into account the magnitude of the pre-treatment score. The larger the pre-treatment score means the more severe the malocclusion at start and consequently a smaller percentage improvement can be categorized as 'greatly improved'. Conversely, a mild malocclusion with a smaller pre-treatment score with a 100% improvement is only categorized as 'improved'. Hence, the PAR scores are also useful in evaluating malocclusion severity, treatment need and difficulty.[14,15,16]

Intra-examiner reliability in PAR scores was assessed by repeating these measurements in 14 cases (about 10% of sample) selected by random numbers (www.randomize.org/form) at least four weeks apart by the same examiner.

Statistical Analysis

Descriptive and inferential statistics were performed with SPSS (version 17) for Windows. Normality tests were done to decide on using parametric or non-parametric tests if the criteria were satisfied. Intraclass correlation coefficients (ICC) were used to assess intraexaminer reliability in PAR scoring[17]. There was normality and homogeneity of variances in the data for treatment time. One-way analysis of variance (ANOVA) was used to test differences in treatment time between different variables. Bonferroni's Post Hoc Multiple comparison was run to compare means in more than three groups. T tests or Mann-Whitney U tests were performed to compare treatment time, number of teeth extracted, failed/changed appointments, pre-treatment PAR score, percent reduction in PAR score and reduction in PAR score between Group 1 and 2. Pearson or Spearman correlation coefficient was used to determine if there was a relationship between the pre-treatment PAR score and the change in PAR score, as well as to establish if there was any association between pre-treatment PAR score and the duration of treatment and whether the mean treatment duration was different in both groups. Kruskal-Wallis test was used to test 3 categories; no change, change of operator within and outside the clinic when the criteria in ANOVA was not met.

Multiple linear regression analysis was used to evaluate the predictive effect of several independent variables on the treatment time. Predictor variables which were statistically significant to treatment time were inserted and removed experimentally to find the models with the strongest value of adjusted R^2 and consequently, the smallest amount of unexplained variance. The initial predictor variables were number of failed/changed appointments, number of operators, extractions and pre-treatment PAR score. *P* values less than 0.05 was considered to indicate statistical significance.

RESULTS

There was excellent intra-examiner reliability with ICC values of 0.99, 0.96, 0.99 and 0.95 for pre-treatment scores, post-treatment scores, reduction in PAR scores and percent improvement respectively. In total there were 142 patients (42 male, 100 female) with ethnic distribution of 56 Malays (39.4%), 45 Chinese (31.7%), 41 Indians (28.9%) and age ranging from 9.6 to 27.0 years. The majority of the malocclusions were Class II Div1 (76.8%) followed by Class I (9.9%), Class III (7.7%) and Class II Div2 (5.6%). Pre-treatment age, type of malocclusion, extraction pattern and pre-treatment PAR score were not statistically significantly different in both Group 1 and 2.

Table 1 shows the mean treatment time for Group 1(2.31, SD .86) and Group 2 (3.25, SD1.23) is significantly different in the *t*-test (p=.0001) and Mann-Whitney U test (p=.0001).

Table 1 Length of treatment

a) *t*-Test for independent samples of group and equality of means

Treatment time (years)	N	Mean	Std. Deviation	Std. Error Mean
Group 1	60	2.31	.86	.11
Group 2	82	3.25	1.23	.14

Levene's Test for equality of variances: *F=5.225, p=.024*

Variances	t-test for Equality of Means						
						95% CI of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal	-5.087	140	.000	-.94126	.18504	-1.30710	-.57543
UnEqual	-5.364	139.789	.000	-.94126	.17547	-1.28818	-.59435

b) Mann-Whitney U - Wilcoxon Rank Sum test

Number of Operators	N	Mean Rank	Sum of Ranks
Group 1	60	51.27	3076.00
Group 2	82	86.30	7077.00

U	*W*	*Z*	Two-tailed *P*
1246.0	3076.0	-5.014	.0001

Tables 2 and 3 shows the mean PAR scores at pre-treatment, post-treatment, reduction and percentage differences in PAR in the total sample and between Group 1 and 2.

Table 2 Mean PAR scores in total sample

Group 1 & 2 N=142	PAR scores			
	Pre-treatment	Post-treatment	Reduction in PAR	% Reduction in PAR
Mean	32.61	3.78	28.82	88.67
Std. Error of Mean	.82	.39	.796	1.05
Median	32.00	2.00	28.00	92.00
Std. Deviation	9.781	4.61	9.486	12.55
Range	10-64	0-29	10-63	29.30-100.00

Table 3 PAR scores before and after treatment

	Mean PAR scores			
	Pre-treatment (SD)	Post-treatment (SD)	Reduction in PAR (SD)	% reduction (SD)
Group 1	32.4 (9.9)	2.6 (2.9)	29.7 (9.1)	92.0 (7.7)
Group 2	32.8 (9.7)	4.6 (5.4)	28.2 (9.7)	86.2 (14.7)

There was a reduction of 92% in the average PAR score for single operator while multiple operators showed a lower figure of 86.2% and this was statistically significant (p=.042)(Table 4).

Table 4 Mann-Whitney U test for pre-treatment, post-treatment, reduction in PAR & percent reduction in PAR scores and failed/changed appointments

	Mean rank of PAR Scores				Mean no. of failed/changed appointments (SD)
	Pre-treatment	Post-treatment	Reduction in PAR	% reduction	
Group 1	70.03	63.18	75.17	79.65	3.9 (3.1)
Group 2	72.58	77.59	68.82	65.54	6.2 (4.1)
Z statistic	-0.366	-2.083	-.909	-2.030	-3.569
2-tailed *p*	0.715	0.037*	0.363	0.042*	.0001

Significance set at p<.05

Although post-treatment PAR scores were not high in both groups; (Group 1=2.6, Group 2=4.6), this was weakly statistically significant (*p*=.037) and there was a wide range in PAR score from 0-29 in the sample (Table 2,3,4). When Group 1 and 2 were compared using the PAR Nomogram, it was found that 71.7% of Group 1 fell into the 'greatly improved' category, and 28.3% in the 'improved' category and nil in the 'worse/no different' category (Table 5). The corresponding figures for Group 2 were 69.5%, 29.3% and 0.7% respectively. Exploring details of the characteristics of PAR Index measurements, it was observed that at post-treatment all cases were completely aligned with some discrepancies in residual overjet, overbite and dental centerline in both groups (Table 5). There were higher proportions of residual discrepancies in the multiple-operator group explaining the higher post-treatment PAR scores.

Table 5 Improvement in PAR from Nomogram and residual overjet (OJ), overbite (OB) and centerline (CL) discrepancies post-treatment

	Nomogram			Residual discrepancies in finished cases			
	Greatly improve	Improve	Worse/ no difference	OJ	OB	CL <1/2 tooth	CL >1/2 tooth
Group 1	43 (71.7%)	17 (28.3%)	0	2 (3.3%)	2 (3.4%)	11 (18.3%)	0
Group 2	57 (69.5%)	24 (29.3%)	1 (1.2%)	15 (18.3%)	7 (8.5%)	20 (24.4%)	5 (6.1%)
Total	100 (40.4%)	41 (28.9%)	1 (0.7%)	17 (11.9%)	9 (6.3%)	31 (21.8%)	5 (3.5%)

Comparing differences in mean PAR scores for pre-treatment, post-treatment, reduction and percentage reduction in PAR scores in cases with no operator change or change within or outside the clinic, no significant difference was observed although there was significant difference (*p*=.0001) in treatment duration (Table 6).

Table 6 Treatment time and PAR scores with change of operators from within and outside clinic with Kruskal-Wallis test

Operator change	Mean rank of PAR Scores and Treatment time				
	Treatment time	Pre-treatment	Post-treatment	Reduction in PAR	% reduction
Within clinic	87.28	71.34	77.34	67.68	66.04
Outside clinic	81.57	77.43	78.79	74.36	63.07
No change	51.27	70.03	63.18	75.17	79.65
Chi-Square	25.361	.369	435.5	1.134	4.183
p	.0001*	.832	.113	.567	.123

Significance set at $p<.05$

Table 4 shows the difference in mean number of failed/ changed appointments between the groups and this was statistically significant (*p*=.001). The number of failed/changed appointments in the total sample ranged from 0-18 with a mean of 5.2(SD,3.8). Correlation tests showed that possible predictors of treatment duration included failed/changed appointments (*p*=.0001), number of extractions (*p*=.05), pre-treatment PAR score (*p*=.05) and number of operators (*p*=.0001). However, multiple linear regression analysis with all these four variables showed that pre-treatment PAR score and number of extractions were not statistically significant (R=.770). Hence a new model with only two variables, failed/changed appointments and number of operators were used in the analysis (Table 7). The model showed that treatment duration was significantly associated with failed/changed appointments (*p*=.0001) and number of operators (*p*=.0001) although this contributed to about 57.5% of possible factors (R=.762).

Table 7 Multiple linear regression of Treatment duration with number of failed/changed appointments and number of operators

	Unstandardized Coefficients		Standardized Coefficients				
Variables	B	Std. Error	Beta	t	Sig.	R	Adjusted R square
(Constant)	.937	.186		5.038	.000		
Number of Change or Failed Appointments	.187	.018	.608	10.467	.000	.762[a]	.575
Number of Operators	.575	.110	.303	5.216	.000		

a. Predictors: (Constant), Number of Orthodontists, Number of Change or Failed Appointments

Variables	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	R	Adjusted R square
(Constant)	.937	.186		5.038	.000		
Number of Change or Failed Appointments	.187	.018	.608	10.467	.000	.762[a]	.575
Number of Operators	.575	.110	.303	5.216	.000		

b. Dependent Variable: Treatment duration

DISCUSSION

This study has shown that there is a significant difference (*p*=.0001) in treatment times between patients treated by a single operator and multiple operators. A change of operators appears to have a profound effect on the total treatment duration, increasing it by an average of 11.3 months. There was positive correlation between total treatment time and reduction in PAR score (p<.05) showing that the more difficult cases may require longer treatment duration. However, a more detailed analysis of cases with treatment time more than four years showed that only 4 (22%) were difficult cases in multiple operators compared with 3 (100%) in single operators. Of the various variables that may be associated with treatment time in both groups, the most significant in this study was the number of failed/changed appointments (p<.0001) and number of operators (p<.0001) which contributed to 57.5% of possible factors. The appointment interval in the current study was routinely between 6-8 weeks unless otherwise requested by patients.

A previous study by the Loke and Tan[2] found that treatment time was associated with the number of appointment changes (r=.638, p<.01) and change in operators (r=.115, p<.01). They reported longer mean treatment duration in single (3.52, SD 1.62) and 2-operator (3.65, SD 1.81) cases compared with the current study mean of 2.31years and 3.25 years. They reported almost doubling of treatment time with more than two operators and almost tripling with change of four or more operators (*p*=.0001) and there was linear association in treatment time with increase in appointment changes (*p*=.0001). This may be due to their sample which included fixed and removable / functional appliances and orthognathic surgery and 45% of patients with 6 or more appointment changes. Robb et al.[18] similarly reported that the number of broken appointments and appliance repairs accounted for about 46% in additional treatment time. McGuiness and McDonald[1] reported much shorter treatment duration in their single operator (17.67 months, SD 4.17) and 2-operator (26.1 months, SD 6.78) groups although in their study the number of broken appointments were the same in both groups. However, it is not clear the reasons for the much longer mean treatment time in the current study for single operators compared with an earlier study (1.33 years; range 4-43 months) in another clinic by the same author with comparable number of missed appointments.[3]

There was longer treatment time when there was a change in operator within or outside the clinic compared with no change although there were no significant differences in pre-treatment, post-treatment and reduction in PAR scores (Table 6).

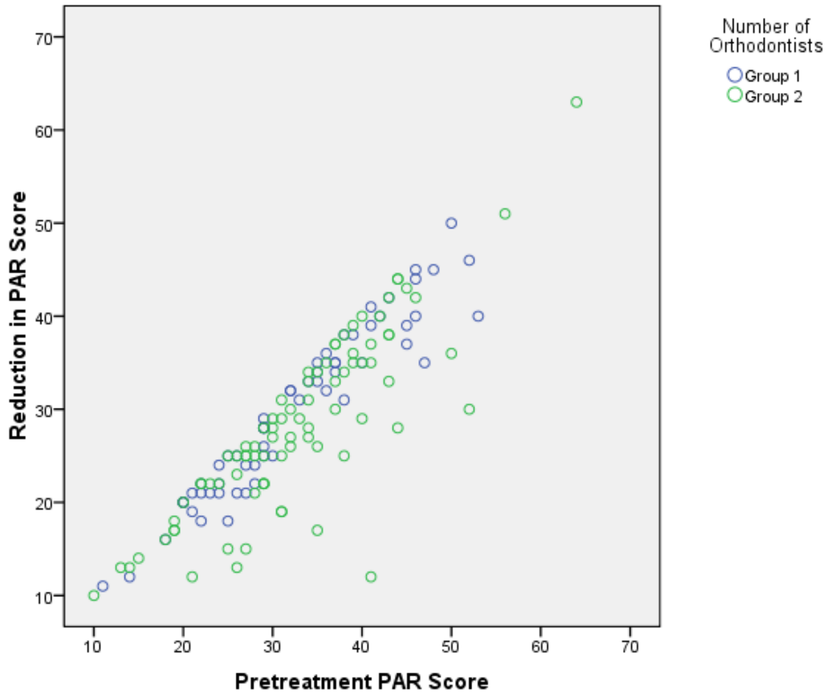
There was generally a high standard of treatment outcomes with mean post-treatment PAR score of 3.8, mean reduction of 28.8 points and

88.7% reduction in PAR scores (Table 2). This was comparable to a similar study by Loke[10] where the mean post-treatment PAR score was 6.4, mean reduction of 27.9 points and 88.2% reduction in PAR scores. However, Radnzic's study[19] of a large sample 17 District General hospital orthodontic departments in England and Wales showed a lower mean percentage PAR reduction of 74.79%, change of 22.24 PAR score, and a post-treatment weighted score of 6.75. The current study found a greater reduction in PAR score of 92% in Group 1 compared with 86.2% in Group 2 and this was statistically significant (*p*=.042) in contrast to McGuiness and McDonald[1] who observed a greater reduction in Group 2 (79.95%) than Group 1 (70.85%). This is seen as a high standard of orthodontic treatment where a reduction in PAR score greater than 70% was considered good standard, and there was only one patient in the 'worse/no different' category[6,7,20]. However, the current study found a statistical difference (*p*=.037) albeit small, in post-treatment PAR scores for group 1 (2.6, SD 2.9) and group 2 (4.6, SD 5.4) contrary to McGuiness and McDonald[1] who showed no significant difference between their single-operator (7.0, SD5.1) and multiple-operator groups (5.6, SD 3.2) (Table 4).

Although the descriptive percent improvement in both groups were similar as assessed by the PAR Nomogram, there were greater differences between the groups observed in the residual discrepancies in overjet, overbite and centerline correction at post-treatment (Table 5). In examining the results of this study, it is interesting to note that Group 1and Group 2 had 71.7% and 40.4% in the 'greatly improved' respectively compared with 50% and 56.7% in McGuiness and McDonald's study. Surprisingly, their study found 6.7% in the 'worse/no different' category in Group 1 compared to nil in Group 2 in contrast to our study with nil in Group 1 and 1.2% in Group 2. They

suggested that no cases found in the 'worse/no different' category in Group 2 were due to the longer treatment time which was not the case in the present study. Other factors contributing to differences in treatment outcomes may be due to difficult cases with impacted teeth, cases with compromised treatment, frequent appliance breakages and failure to attend regular treatment.[2,3,5,10,16,20] Riedmann and Berg[21] reported lower mean percentage reduction in PAR score in compromised cases (37%) than ideal cases (73%); similarly Loke[10] reported 84.7% in routine and 69.2% in compromised cases; and Fox[16] observed that 36.3% of their 'worse/no different' cases were due to compromised treatment. Hence, it is not inconceivable that the finishing of the malocclusion is compromised with loss of control by the subsequent operator with the increased number of failed/changed appointments and non-continuity of care by the same operator.
A highly linear relationship (Pearson's r=.889) was found between the initial PAR score and the change in PAR score for both groups, suggesting that the overall change in PAR score can be predicted before treatment from the pre-treatment score (Figure 1). However, the better correlation in Group 1 (r=.958) than Group 2 (r=.846) suggests that the predictability of the change with treatment was less in cases treated by multiple operators.

Figure 1 Relationship between pre-treatment PAR score and PAR score reduction for groups 1 and 2 (r=.889)



Limitations of the study

Ideally, the PAR scoring is done by another person other than the attending orthodontist to reduce possible bias. Limitations associated with PAR scoring relate mainly to the weighting system, particularly the overjet and overbite.[6,16,19] The high weightage for overjet may influence the Index to such an extent that is may be unduly sensitive in any malocclusion where overjet is increased. For example, a much improved overjet by retroclination of the upper incisors will reduce the PAR score greatly although the aesthetic and functional benefit may be questionable since the index does not take into account the inclination of the incisors. On the other hand, the weightage for overbite is low, so the correction of a traumatic overbite may be reflected by only a small reduction in PAR but may actually represent a huge improvement in function and aesthetics.

CONCLUSION

Change of operator contributes significantly to a lengthening of treatment duration in fixed appliance therapy by about 11.3 months. The standard of treatment was high in both groups with an average 86-92% reduction in PAR score, 2.6-4.6 in post-treatment PAR score and 0.7% cases in the 'worse/no different' category. However, there was weak statistical significant difference in the post-treatment PAR score (p=.037) and percent reduction in PAR score (p=.042) between single and multiple operators. This study observed that the overall reduction in PAR score during treatment can be predicted from the pre-treatment PAR score more accurately in single operators than multiple operators and the multivariate predictive model of failed/changed appointments and operator change explained 57.5% of the variation in treatment time. This study highlights the fact that patients who have frequent appointment changes or irregular attendances and change in operator care are compromised with respect to increased treatment duration and quality of finish of treatment results.

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