Orthodontic Treatment with Fixed Appliances in the General Dental Service in Scotland

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Abstract. *The records of 128 subjects treated by orthodontic specialists with fixed appliances in the General Dental Service in Scotland were randomly selected from the Scottish Dental Practice Board for analysis. The results of the study revealed that: (1) Mean post-treatment Peer Assessment Rating was 7·8 ± 4·6 PAR points. (2) Mean reduction in PAR score was 14·9 ± 10·6 PAR points. (3) Mean percentage reduction in PAR was 59 per cent. (4) Twenty-eight per cent of the cases were 'greatly improved', 15 per cent of the cases were made 'worse or no different'. (5) Median duration of treatment was 15 months, with a range of 2–41 months. (6) Multiple regression analysis showed that 82 per cent of the variability of PAR change could be predicted by the pretreatment PAR scores and the number of arches treated. Post-treatment PAR scores and duration of treatment could not be predicted with adequate reliability. It was concluded that although about 75 per cent of the cases were treated to at least acceptable alignment and occlusion, the modest average percentage reduction in PAR score could be explained by the low average initial PAR score and the borderline need for treatment in many cases.*

Index words: Fixed Appliances, PAR Index.

Introduction

Over the past two decades, many studies have been conducted to investigate the standard and outcome of orthodontic treatment and the associated factors. Generally speaking, orthodontic care provided by the Hospital Service (Table 1) has produced superior treatment results to that provided by the General Dental Service (Table 2). Previous studies showed that, among other factors, severe pretreatment malocclusions, use of fixed appliances, and two-arch appliance therapy brought about more improvement as a result of orthodontic treatment than mild pretreatment malocclusions, use of removable appliances, and 1-arch appliance therapy (Table 3). However, the type of orthodontic appliance used, the operator's qualifications and experience may be all related to the pretreatment severity of the malocclusions treated (Fox *et al.*, 1997), since severe malocclusions tend to be treated with fixed appliances in the Hospital Service.

Aims of the Study

This study was undertaken in order to evaluate the quality and duration of orthodontic treatment results of cases treated with fixed appliances in the General Dental Service in Scotland.

The specific objectives were:

(1) to investigate the treatment outcome in terms of the quality of result, as measured by the PAR Index, and the duration of treatment.

(2) to identify factors which were associated with, and predictive of, treatment quality.
(3) to identify factors which were associated with, and predictive of, duration of treatment.

Materials and Methods

Pre- and post-treatment study casts and information 180 cases treated with fixed appliance therapy in the General Dental Service (GDS) in Scotland were collected consecutively according to Scottish Dental Practice Board random sampling procedures. The treatment of these cases was completed between December 1993 and July 1994.

The following information was available:

1. Gender of subjects.
2. Date of birth.
3. Age at start of treatment.
4. Dates of commencement and completion of treatment.
5. Extraction pattern.
6. Details of appliances used.
7. Appliance breakages, repairs, etc.
8. Whether or not consultant advice had been obtained.
9. Operator type (specialist, GDP).
10 Fees paid for the treatment.

After eliminating cases with absent data, damaged study models, or study models where it was impossible to ascertain the articulation, 134 cases remained.

It was found that only five out of 134 cases were treated by General Dental Practitioners and one by a consultant. In

order to produce groups suitable in size for regression analysis, the operator type included in this study was reduced to those treated by orthodontic specialists only. Consequently, a sample size of 128 cases treated homogeneously by orthodontic specialists was produced. The mean age at commencement of treatment of these subjects was 14·1 years (range 8·8–47·7).

The data collected from the study casts and case information were categorized into three groups of variables (Table 4).

PAR (Richmond *et al.*, 1992) scores and IOTN (Brook and Shaw, 1989) assessment were performed by one examiner (LHT) who had been calibrated in their use.

Error Study

After a period of at least 1 month, 15 pretreatment and 15 post-treatment sets of dental casts were selected by ballot for re-assessment by the same examiner. The variables re-assessed on the dental casts in the error study were :

1. Developmental stage of dentition.
2. Incisor relationship.
3. Molar and canine relationship.
4. Overjet.
5. Other occlusal features.
6. IOTN.
7. PAR scores.

TABLE 1   *Treatment outcome and standard in hospital orthodontic service*

Study	Sample	Index	Results
Pickering & Vig (1975) (England)	321 cases treated with either FA or RA	Occlusal index	On average, cases fell into 'minor treatment need' group OI score = 4·6–7·0
Tang & Wei (1990) (Hong Kong)	67 cases treated with FA	Occlusal index	On average, cases fell into 'good occlusion' category OI score = 1·6
O'Brien *et al.* (1993) (England & Wales)	1392 cases treated with FA	PAR index	Mean percentage reduction in PAR for: 2-arch FA = 75·5% 1-arch FA = 59·4%
Richmond (1993) (England)	51 cases treated with FA	PAR index	Mean percentage reduction in PAR = 74%
Fox (1993) (England)	92 cases treated with FA	PAR index	41% were 'greatly improved', 12% were made worse or no different
Kerr *et al.* (1993) (Scotland)	150 cases treated with RA	PAR index	Mean percentage reduction in PAR = 52%
Taylor (1994) (Scotland)	156 cases treated with a variety of appliances	PAR index	Full FA treatment, mean PAR change = 21, mean percentage change in PAR = 65%
Buchanan *et al.* (1996) (Scotland)	82 cases treated with FA	PAR index	Mean percentage reduction in PAR = 74%
Birkeland *et al.* (1997) (Norway)	224 cases treated with FA	PAR index	Mean percentage reduction in PAR = 77%

TABLE 2   *Treatment outcome and standard in the General Dental Service*

Study	Sample	Index	Results
Berg (1979) (Norway)	164 cases treated with FA	—	50% of the cases did not achieve treatment objectives
Elderton & Clark (1983) (Scotland)	256 cases	Occlusal index	Mean reduction in score = 4·4 30% either showed no change or deteriorated.
Elderton & Clark (1984) (Scotland)	51 cases with RA	Occlusal index	25% improved from 'worse occlusion' or 'definite need for treatment' categories to 'good occlusion' or 'no need treatment' categories
Richmond *et al.* (1993) (England & Wales)	1010 prior approval cases	PAR index	Mean percentage reduction in PAR = 55%; 1-arch FA group = 54·6% 2-arch FA group = 71·4%
Richmond & Andrews (1993) (Norway)	212 cases treated with FA	PAR index	Mean percentage reduction in PAR = 78%
Kerr *et al.* (1996) (Scotland)	150 cases treated with RA	PAR index	Mean percentage reduction in PAR = 46%
Kelly & Springate (1996) (England & Wales)	200 cases treated with FA	PAR index	Mean percentage reduction in PAR = 89%, mean PAR change = 24
Turbill *et al.* (1996b) (England & Wales)	1500 cases treated with FA or/& RA	PAR index	Mean percentage reduction in PAR = 53·9% 1 - arch FA group = 60% 2 - arch FA group = 64·8% RA group = 42·9%
Fox *et al.* (1997) (England)	375 sets of start models, 250 sets of end treatment models, treated with a variety of appliances	PAR index	Mean percentage reduction in PAR = 60 %

TABLE 3 *Factors affecting orthodontic treatment outcome and standards*

Factors	Studies
Pretreatment severity of malocclusions	Berg & Fredlund (1981)
	Kerr *et al.* (1994, 1996)
	Taylor *et al.* (1996)
Fixed appliances superior to removable appliance therapy.	Pickering & Vig (1990)
	Tang & Wei (1990)
	O'Brien *et al.* (1993)
	Taylor (1994)
	Turbill *et al.*, (1996a)
2-arch appliance therapy better than 1-arch appliance therapy.	O'Brien *et al.* (1993)
	Fox (1993)
	Richmond *et al.* (1993)
Type of mechanics used	Buchanan *et al.* (1996)
Others	
Operators' qualification	Fox *et al.* (1997)
Operators' experience	O'Brien *et al.* (1993)
Aspiration of consultants & supporting staff	O'Brien *et al.* (1993)
Discontinuation of treatment	Myrberg & Thilander (1973)
	Fox *et al.* (1997)

TABLE 4 *Categorization of variables*

Patient factors	Treatment factors	Outcome variables
Gender	Operator Type	Post-treatment PAR scores
Age	Advice from consultant	Change in PAR scores
Development stage of dentition	Number of arches treated	Percentage change in PAR scores
Overjet	Extraction patterns of improvement	Nomogram classification
Incisor relationship	Use of removable appliances (in addition to fixed)	Duration of treatment
Molar and canine relationship	Use of palatal or lingual arches	
Other occlusal factors cross-bite, anterior spacing, rotation, ectopic tooth, etc.	Use of extra-oral traction	
IOTN: DHC & AC	Number of appliance repair and breakages	
Pretreatment PAR scores	Fees for treatment	

Statistical Analysis

For the error study, intra-examiner agreement for discrete data was measured using Kappa Statistics. Intra-examiner reliability for PAR scores was measured by Intra-class Correlation Coefficient.

Preliminary statistical analysis was performed on all variables to describe the sample profile. The PAR nomogram was used to classify the results of orthodontic treatment into three categories, namely 'greatly improved', 'improved', and 'worse or no different'.

Multiple linear regression was used to model treatment results or standard, and duration of treatment. These equations would explain the relationship of the potential predictor factors with the treatment standard and duration.

Results

The results of the error study are shown in Table 5.

Both Intra-class Correlation Coefficient and Kappa Statistics showed good or very good intra-examiner reliability in measurements of continuous and discrete vari-

TABLE 5 *Intra-rater reliability*

Categorical variables	κ Values
Developmental stage of dentition	0·76
Incisor relationship	0·63
Molar relationship	0·86
Canine relationship	0·81
Overjet classification	0·87
Presence of cross-bite	0·84
Anterior spacing	0·84
Presence of rotated teeth	0·27
IOTN: Dental Health Component	0·90
IOTN: Aesthetic Component	0·86

ables. An apparent exception was in identifying the 'presence of rotated tooth', with a Kappa value of 0·27, which demonstrated only slight strength of agreement. However, this was due to a statistical artefact. Eighty-seven per cent of the cases were actually in agreement where 'presence of rotated tooth' was concerned, the poor Kappa value being wholly due to there being no rotation in almost all cases.

Intra-class Correlation Coefficient (R) performed on PAR scores produced a value of 0·93, indicating high level of intra-examiner agreement in assessment of PAR scores.

The categorization of the sample before treatment (T_1) according to IOTN is shown in Figures 1 and 2.

The change in PAR score ($T_1 - T_2$) as a result of treatment is shown in Table 6 and the nomogram classification in Figure 3.

The mean (SD) duration of treatment was 15·3 ± 6·9 months.

Regression analysis produced the following equations predictive of post-treatment PAR, PAR change and duration of treatment:

Post-treatment PAR = 11·2 – 2·54(Number of arches treated) + 2·84 (if rotation is present) R^2 = 11·0 per cent

PAR change = –9·95 + 0·93(Pre-PAR) + 2·27(Number of arches treated) R^2 = 81·9 per cent

Duration = 8·38 + 0·05(Pre-PAR) + 1·79(Extraction) + 2·25(Fees) + 1·16(Number of Repairs) – 2·85(Developmental Stage) + 1·47(DHC) R^2 = 29·2 per cent

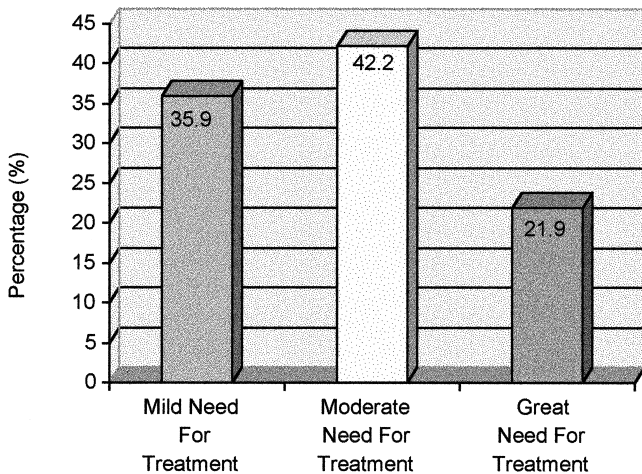

FIG. 1   Aesthetic component (IOTN) – T_1.
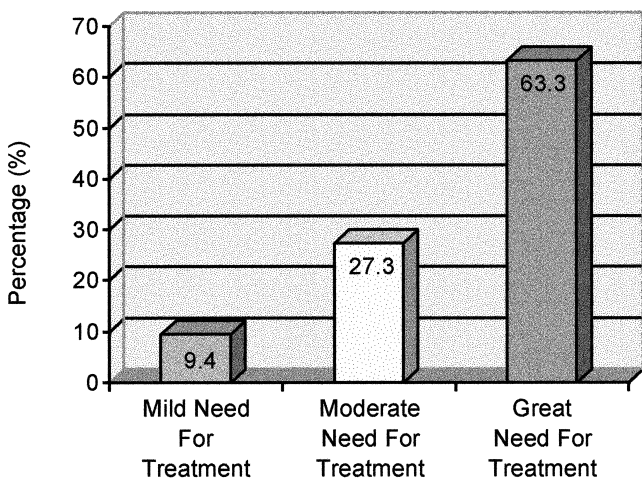

FIG. 2   Dental Health Component (IOTN) – T_1.
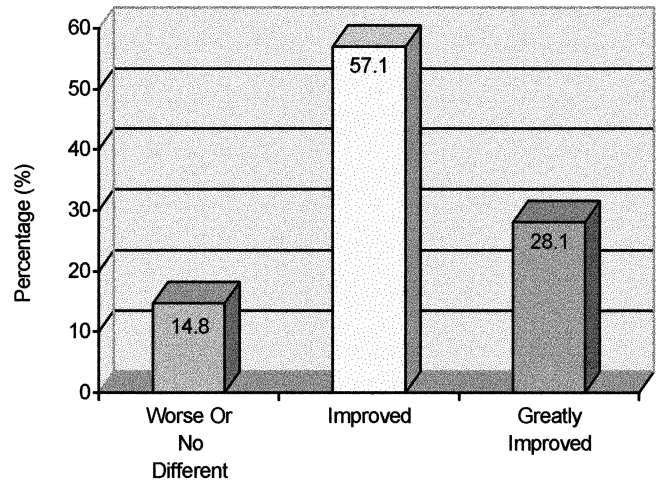
FIG. 3   Nomogram classification of PAR improvement ($T_1 - T_2$).

TABLE 6   *Treatment outcome measured by PAR Index*

	Mean	SD	Min.	Max.
Pretreatment PAR	22·7	9·9	6·0	50·0
Post-treatment PAR	7·8	4·6	2·0	23·0
PAR change	14·9	10·6	–10·0	48·0
Percentage PAR change	59·2	31·9	–142·9	96·0

Extraction pattern, fees and developmental stage were coded in bands.

A total of 62·5 per cent of subjects had two-arch fixed appliance therapy and 37·5 per cent one arch therapy.

Discussion

IOTN at baseline

Dental Health Component. From the data of this study, it was revealed that only about two-thirds (63 per cent) of the cases treated with fixed appliance therapy in the GDS in Scotland were in definite need for treatment on dental health grounds.

Compared with 87 per cent in the Hospital Service (O'Brien *et al.*, 1993), and 80 and 73 per cent in the GDS (Richmond *et al.*, 1993; Turbill *et al.*, 1996) in England and Wales, the proportion of patients in definite need of treatment was rather low.

Aesthetic Component. On aesthetic grounds, only 22 per cent of the cases treated with fixed appliance therapy in the GDS in Scotland were in definite need of treatment, whereas more than three-quarters of the cases had either a mild or borderline need for treatment.

The large discrepancy between the assessment with Dental Health Component and Aesthetic Component may be explained by the fact that some cases which scored low in the Aesthetic Component may have had traits which require orthodontic correction on dental health grounds, but which did not register on the aesthetic scale. This discrepancy has also been shown by Turbill *et al.* (1996).

PAR Score

The mean pretreatment PAR score in this study was 23. Considering that a PAR reduction of 22 was needed to bring about 'great improvement' in a treated case (Richmond *et al.*, 1992), the mean PAR score in this study was not sufficiently high to produce great improvement after orthodontic treatment.

The average post-treatment PAR score in this study was 8, indicating that the cases were generally treated to acceptable alignment and occlusion (Richmond *et al.*, 1992).

A PAR reduction of 15 points in this study supported the finding that a low pretreatment PAR score could not result in great improvement in alignment and occlusion of a treated case.

Percentage PAR reduction of 30 per cent was required for a case to be 'improved', whereas a mean percentage PAR reduction of more than 70 per cent was needed to show that the standard of treatment was high (Richmond *et al.*, 1992). The mean percentage reduction in PAR score of 59 per cent in this study was modest for a fixed appliance group. This is in contrast with the Hospital Service in England and Wales (O'Brien *et al.*, 1993), and the GDS in England and Wales (Richmond *et al.*, 1993), where the percentage reductions in PAR were 68 and 71 per cent, respectively. It is also worth noting that 59 per cent improvement is only marginally better that the 56 per cent improvement shown by Kerr *et al.* (1993) in a study with removable appliances in the Hospital Service.

Categorization of Improvement

It was suggested that treatment standard was considered high if the proportion of cases in the 'worse or no different' category was negligible (Richmond *et al.*, 1992), ideally less than 5 per cent (Richmond, 1993), and a high percentage of cases having been 'greatly improved' should be greater than 40 per cent (Richmond *et al.*, 1992). In view of this, the standard of treatment in the GDS of Scotland could be said to be less than satisfactory, having only 28 per cent of the cases being 'greatly improved', and 15 per cent of the cases made worse or no different after treatment, although majority of the cases (85 per cent) was at least improved due by treatment.

In general, the rather disappointing outcome in many cases could be explained by the fact that treatment need was borderline and the malocclusions, in many cases, mild with low initial PAR scores. Whereas it may be that it is more appropriate to treat severe malocclusions in a Hospital environment and milder ones in Specialist Practice there must be a threshold below which the benefit to patients is so small as to question the appropriateness of treatment within the National Health Service.

Duration of Treatment

The median time taken to complete treatment in cases treated with fixed appliances in the GDS of Scotland was 15 months. The shortest duration was 2 months and the longest 41·0 months.

The mean treatment time calculated in this study was shorter than those found in other studies. The short treat-ment duration may be due to the fact that, in some cases, initial study casts were taken only after extractions had been performed, although the fixed appliances had not yet been attached to the teeth. This may result in some under-estimation of duration of treatment. However, it was also accepted that, in other cases, there may be a slight over-estimation of treatment duration in that there may be a delay between taking the initial study casts and com-mencing treatment. Short treatment duration may reflect the low initial PAR scores, but may also be related to efficient work practices or that treatment is ended before optimal goals are reached. However, the excessive range of treatment times makes generalization difficult.

Regression Analysis

Post-Treatment PAR Scores. The model showed that post-treatment PAR scores would be reduced by about 5 PAR points, on average, when two-arch fixed appliance treatment was employed in treatment, as compared to only 2·5 PAR points reduction, on average, if single-arch treatment was used. Presence of rotated tooth would increase post-treatment PAR scores by almost 3 PAR points according to this regression model.

However, the R^2 value of this model was just 11 per cent. This meant that only 11 per cent of the variability of post-treatment PAR scores could be explained by number of arch(es) treated with fixed appliances and presence of rotated teeth. Consequently, there were no variables that could accurately and precisely predict the end result.

PAR Change. The model showed that for every point increase in pretreatment PAR score, the PAR reduction would be increased by 0·93 points, on average. Whereas two-arch fixed appliance treatment would increase PAR reduction by 4·5 PAR points, on average, single-arch fixed appliance treatment would increase the PAR difference only by half that figure.

The R^2 value for this model was 81·9 per cent. This meant that almost 82 per cent of the variability of PAR change could be explained by pretreatment PAR scores and the number of arch(es) treated with fixed appliances. The model thus could be used to predict pretreatment and post-treatment PAR difference with reasonable precision.

This study also confirmed the findings of previous studies that the number of arches treated with fixed appliances could be a strong predictor for success of treatment. Two-arch fixed appliance would produce a greater average reduction in PAR score than single-arch treatment for patients with the same initial PAR score.

Duration of Treatment. According to the regression model for treatment duration, with every increment of one PAR point, the treatment duration would be increased by 0·05 months, on average. Duration was also increased by an average of 1·8 months more in extraction cases than non-extraction cases and with appliance repair treatment duration would be increased by 1·2 months, on average. An increase of one grade in the Dental Health Component of IOTN would prolong treatment duration by 1·5 months, on average. Average duration of treatment was longer in the mixed dentition than the permanent dentition.

However, the R^2 value of this regression model was only 29·2. This meant that only about 29 per cent of the variability of duration of treatment could be predicted by this model. Therefore, it could be concluded that, although pretreatment PAR scores, extraction patterns, fees paid for treatment, number of appliance breakages and repairs, developmental stage of dentition and IOTN gradings may be used as factors to predict duration of treatment with fixed appliances in the GDS of Scotland, the precision of the prediction was rather low.

Conclusions

On average, cases treated with fixed appliances in the GDS in Scotland, were treated to an acceptable alignment and occlusion (i.e. mean post-treatment PAR score <10).

However, these results failed to meet the standards of improvement set by other authors for GDS fixed appliance treatment, in that the mean reduction in PAR points was only 15 (i.e. <22).

The median time to complete fixed appliance orthodontic therapy in the GDS in Scotland was 15 months (range 2–41 months).

Multiple Regression Analysis showed that the post-treatment PAR score and treatment duration to be highly unpredictable.

Almost 82 per cent of the variability in PAR change was explainable by just two factors, the pretreatment PAR score and the number of arches treated.

Acknowledgements

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