



Zahran, S., McDonald, F., & Sherriff, M. (2018). Efficiency and effectiveness of orthodontic treatment within United Kingdom secondary care: a service evaluation. *Journal of Orthodontics*, 45(3), 169-175.  
<https://doi.org/10.1080/14653125.2018.1490871>

Peer reviewed version

Link to published version (if available):  
[10.1080/14653125.2018.1490871](https://doi.org/10.1080/14653125.2018.1490871)

[Link to publication record in Explore Bristol Research](#)  
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via Taylor & Francis at <https://www.tandfonline.com/doi/full/10.1080/14653125.2018.1490871> . Please refer to any applicable terms of use of the publisher.

## University of Bristol - Explore Bristol Research

### General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:  
<http://www.bristol.ac.uk/pure/about/ebr-terms>

## **Abstract**

**Objectives:** To evaluate the efficiency and effectiveness of Orthodontic treatment in the National Health Service (NHS) hospitals in England and to identify factors that may be predictive of the duration of Orthodontic treatment and number of patients' visits.

**Materials and methods:** The data was collected from the clinical notes, the hospital data base and the pre and post treatment study models of 70 patients who were treated with fixed appliances within the orthodontic departments of two NHS hospitals. The pre and post treatment models were assessed using the Index of Orthodontic Treatment Need (IOTN) and the Peer Assessment Rating (PAR) index.

**Results:** 1) 98.5% of the patients treated with fixed appliances in both hospitals were in definite need for treatment, 2) The mean percentage PAR score reduction was 81.5%, 3) The mean treatment duration was 27 months with an average of 21 appointments, 4) Retention duration was found to be an average of 10 months with 2 review appointments during this period, 5) The most common retention regimen was upper and lower Essix retainers, 6) 14% of the patients were treated by 2 operators whereas around 85% were treated by 1 operator, 7) Factors increasing treatment duration included being a female patient, a class I malocclusion, IOTN 5, treatment involving extractions, prescribing headgear wear, the use of functional appliances or quadhelixes and increased number of missed appointments, 8) Factors reducing the treatment time were male patients, class II or class III malocclusions and an increased number of emergency appointments, 9) Extractions increased the number of appointments but did not affect the percentage reduction in PAR score.

**Conclusions:** The hospitals demonstrated a high standard of orthodontic treatment. The small number of patients who fell into certain categories limited the predictive ability of examining these variables within these categories.

**KEYWORDS:** Orthodontic treatment, service evaluation, treatment duration, treatment efficiency.

## **Introduction**

Orthodontic treatment should be assessed from two aspects. The first is its effectiveness, which can be defined as how well the treatment works and how effective it is in managing the patient's problems. Since no treatment strategy works flawlessly all the time, effectiveness should be measured in terms of the average amount of improvement, or in clinical investigations, the proportions of patients with outstanding, good, and poor results. Effective treatment should result in a great improvement and a high proportion of the patients have an excellent result. The second perspective is efficiency, which can be defined as how much benefit the patient gets in relation to the costs and hazards of treatment. The term "cost" means more than just money. There are also other aspects that can affect both the patient and the orthodontist like treatment duration, number of patient appointments and emergency visits to manage problems. Efficient treatment should result in great benefits with minimal cost and insignificant risks (Ackerman 2004).

It is essential to use valid and reliable measures of outcome to obtain data on treatment efficacy (DeGuzman et al. 1995). A useful and a quite simple measure which may be used for orthodontic outcomes research is an occlusal index (Templeton et al. 2006). Many indices have been established with the purpose of classifying malocclusions into different groups, based on the priority and need for treatment (Salzmann 1968; Summers 1971; Linder-Aronson 1974; Lundström 1977; Brook and Shaw 1989).

The Peer Assessment Rating (PAR) Index and the Index of orthodontic treatment need (IOTN) are used extensively in the United Kingdom as orthodontic audit tools. They have provided valued information on the quality of the general dental service (GDS) orthodontics (Brook and Shaw 1989; Richmond et al. 1992a).

### Treatment Duration

Even though average treatment durations of 1 to 2 years are considered classic, the effort to decrease orthodontic treatment time continues (Turbill et al. 2001). Currently, there are no

established national guidelines as to what a gold standard for treatment duration is (Parbatani et al. 2010).

In a study by Fink and Smith (1992), they concluded that the source of variation in treatment duration was the time spent in finishing by individual practitioners. Kelly and Springate (1996) examined the results of fixed upper and lower appliance orthodontic treatment from 10 specialist practitioners. They found that the mean treatment duration was associated with the use of extra-oral forces. McGuiness and McDonald (1998) found that change of operator could result in significant increase in treatment duration in fixed orthodontic appliance treatment with an average of 8.43 months. However, no significant differences were found regarding the quality of orthodontic treatment results, as measured by the PAR Index. Turbill et al (2001) conducted a retrospective study to detect the factors which affect the duration of treatments in NHS practices. They found that factors which can increase treatment duration were treatment by using fixed appliances, extractions of premolars, several stages in the treatments, and improvement of anteroposterior buccal occlusion. Other factors like age, buccal segment malocclusion and IOTN grade 5 and orthodontically qualified practitioners were also linked with slightly longer treatments. They concluded that treatment duration may be affected by the complexity of malocclusion and the careful treatment approach.

Orthodontists have always searched for mechanisms of improving treatment efficiency by reducing the orthodontic treatment time and the length of orthodontic appointments as well as getting the best possible treatment results (Stolzenberg 1935).

Accordingly, the purpose of this retrospective study was to evaluate the efficiency and effectiveness of Orthodontic treatment in the NHS hospitals in England with the following specific objectives:

- 1- To investigate the treatment outcome in terms of the quality of the treatment, as measured by the PAR index, the duration of treatment and number of patients' visits during treatment.
- 2- To assess the outcome of orthodontic treatments in patients treated with extractions and compare it with the outcome of patients treated without extractions, using the PAR index. The null hypothesis was that there was no difference in outcome between patients treated without extractions and those treated with extractions.
- 3- To identify factors that can be linked with and may be predictive of the duration of Orthodontic treatment and number of patients' visits.

## **Materials and methods**

The materials for this study consisted of the hospital notes, the hospital data base and the pre and post treatment study models of 70 patients treated with fixed appliances within the orthodontic departments of Guy's hospital and King's college hospital, 30 patients from the former hospital and 40 patients from the latter.

The subjects for this study were either patients whose active treatments were completed but were still in retention; or patients who were discharged from the orthodontic department after finishing active treatment. For this reason, the study was an audit as treatment was not modified.

Exclusion criteria included:

- 1- Patients who will need orthognathic surgery as part of their treatment
- 2- Patients with cleft lip and/or palate or other craniofacial syndromes
- 3- Absent data and missing or damaged study models

At both sites, the following details of patients were obtained from the orthodontic patient database and the hospital notes:

- 1- Date of birth and age at the commencement of treatment
- 2- Gender of subjects
- 3- Details of the patient's Malocclusion
- 4- Details of the Orthodontic treatment and appliances provided
- 5- Date of Diagnosis, defined as "The date the patient was accepted for Orthodontic treatment and placed on the waiting list"
- 6- Date of beginning of treatment, defined as "The date the patient was booked with the operator for treatment" and date of completion of Orthodontic treatment "The date of debond and beginning of Retention regimen"
- 7- Dates of discharge/last review
- 8- Number of appointments during Orthodontic treatment

- 9- Number of Emergency appointments/ Missed and rescheduled appointments
- 10- Number of operators during Orthodontic treatment
- 11- Retention regimen and how often the patients were seen during the retention period

Each patient's IOTN was assessed by using the patient's notes and pretreatment study models.

The PAR scores of the initial (pretreatment) study models and that of the final (day of debond) study models were obtained which will give an indication of the quality of treatment. The PAR scores were obtained by the use of the Peer Assessment Rating transparent ruler (Richmond et al. 1992a).

**Statistical analysis:**

The repeatability of the scores was tested by re-scoring 20 study models randomly picked and analysed at 2 time points 2 weeks apart by a trained and calibrated assessor. The Intra-examiner reliability was described by the correlation between the difference and mean of the first and second PAR scores, and further analysed by Pearson correlation coefficients.

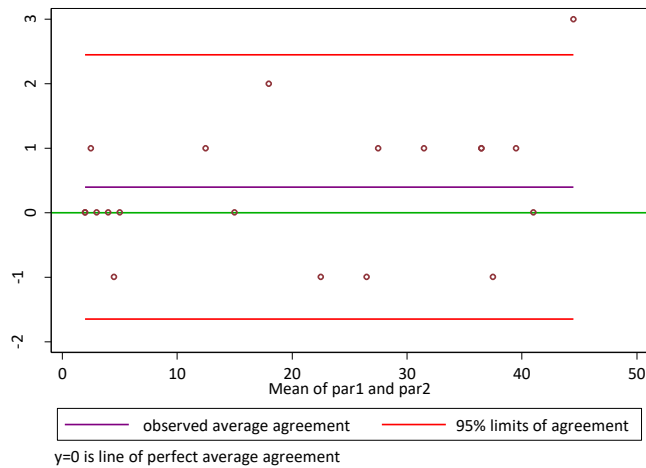
Agreement between the 1st and 2nd measurements was analysed with Bland-Altman plots (Bland and Altman 1986) by using 95% limits of agreement.

Poisson regression was used as it is tailored to describe count variables such as the number of appointments and treatment duration in days in this study. Stata statistical software (Release 13. College Station; TX: StataCorp LP) was used and statistical significance was set at the 5% level.

## Results

### Intra-examiner agreement:

The intra-examiner agreement was high ( $>0.99$ ) and systematic errors assessed with the Bland-Altman plots (Bland and Altman 1986) included no clinically relevant discrepancies demonstrating a high level of reliability (Figure A).



Correlation between difference and mean = 0.326.  
P= 0.10058

### Baseline data:

Table 1 shows information regarding age, sex, initial malocclusion as per the Incisor classification, treatment need, treatment modality, number of operators during treatment and the retention regimen.



	Number	Percentage
<b>Age of patients</b>		
< 20 years	65	92.8
>=20 years	5	7.1
<b>Sex</b>		
Females	43	61.4
Males	27	38.5
<b>Initial malocclusion (Incisor classification)</b>		
Class I	6	8.5
Class II/1	27	38.5
Class II/2	9	12.8
Class III	28	40
<b>IOTN</b>		
IOTN 4	43	61.4
IOTN 5	27	38.5
<b>Treatment</b>		
Non-extraction	37	52.8
Extraction	33	47.1
Functional (Twin block)	8	11.4
Headgear	12	17.1
Quadhelix	7	10
Expose and bond/ traction of Ectopic Maxillary canine	2	2.8
<b>Number of operators</b>		
1	60	85.7
2	10	14.2
<b>Retention regimen</b>		
Lower Essix	1	1.4
Upper Begg-Lower Begg	1	1.4
Upper Begg-Lower Hawley	1	1.4
Upper Essix	1	1.4
Upper Essix-Lower Essix	27	38.5
Upper Essix-Lower Essix / Hawley	2	2.8
Upper Essix-Lower Essix/ Fixed retainer	1	1.4
Upper Essix-Lower Hawley	1	1.4
Upper Essix/Fixed retainer	1	1.4
Upper Hawley	3	4.2
Upper Hawley-Lower Essix	12	17.1
Upper Hawley-Lower Hawley	18	25.7
Upper Hawley/ Fixed retainer	1	1.4

**Treatment duration, waiting list duration, Retention duration and number of visits:**

Table 2 contains information on the average waiting list duration ( $134.2 \pm 97$  days), the average treatment duration ( $823 \pm 240$  days), the number of appointments during treatment ( $20 \pm 5.7$ ), total retention time ( $307 \pm 165$ ), number of retainer review appointments ( $2.5 \pm$

1), number of broken or rescheduled appointments during treatment ( $5.4 \pm 4$ ) and the number of emergency appointments ( $1.8 \pm 1.4$ ).

	Number	Mean	SD	Median	IQR	Min	Max
<b>Waiting list duration (days)</b>	70	134.2	97.5	140.5	197	0	317
<b>Treatment duration (days)</b>	70	823.6	240.8	823.5	298	325	1457
<b>Appointments during treatment</b>	70	20.2	5.7	21	8	9	33
<b>Retention duration (days)</b>	70	307.8	165.8	320	236	0	639
<b>Visits during retention</b>	70	2.5	1.3	2	2	0	6
<b>Broken/Rescheduled appointments</b>	70	5.4	4.3	4.5	5	0	19
<b>Emergency appointments</b>	70	1.8	1.4	2	2	0	6

Data are presented as Mean, Standard deviation (SD), Median, interquartile range (IQR), minimum values (Min) and maximum values (Max).

#### PAR changes:

Table 3 shows dento-occlusal changes due to treatment as measured by the PAR index. The mean percentage improvement is 81.5% with 68.5% of cases being 'greatly improved' and 30% of cases being 'Improved'. Only 1.4 % of cases fell into the 'Worse or no different' category.

	Pretreatment PAR score	Post treatment PAR score	Reduction in PAR score	Percentage change in PAR score
<b>Mean</b>	33.8	5.9	27.8	81.5%
<b>SD</b>	11.4	5.5	10.7	12.4%
<b>Min</b>	13	2	5	27.8%
<b>Max</b>	63	44	55	94.4%

Data are presented as Mean, Standard deviation (SD), minimum values (Min) and maximum values (Max).

### Variation in PAR with Extraction:

There was no statistical difference between the non-extraction and extraction groups in terms of PAR score reduction (Table 4).

	Number	Mean	SD	[95% Conf. Interval]	
<b>Extraction</b>	37	79.4	14.7	74.5	84.3
<b>Non-extraction</b>	33	83.9	8.7	80.8	87.05
<b>Combined</b>	70	81.5	12.4	78.6	84.5
<b>Difference</b>		-4.48		-10.3	1.4

Where, Difference = mean (Non-extraction) – mean (Extraction)

P= 0.1338

### Factors affecting the number of appointments:

Table 5 shows the differences in number of appointments with Sex, IOTN, Extraction and using different treatment methods. IRR stands for Incidence-rate ratio. If it is 1 then there is no effect. If IRR is greater than 1 then the predictable variable has increased effect and if less than 1 then the effect is reduced.

Extractions had a significant effect on the number of appointments during treatment (P=0.01) compared to patients treated with no extractions where the IRR was 1.16 indicating an increase in the number of appointments with increased extractions in patients.

There was no significant difference in the number of appointments between males and females (P=0.20) in the different groups of malocclusion or in the IOTN. Appliance type, whether quadhelix, Functional appliance or Headgear, had no significant effect on the number of appointments. Only treatment by Expose and bond/traction of ectopic maxillary canine showed significant effect on the number of appointments (p=0.02).

Number of appointments	IRR	P	[95% Conf. Interval]	
<b>Sex</b>				
<b>F</b>	1 (base)			
<b>M</b>	0.92	0.205	0.82	1.04
<b>Malocclusion</b>				
<b>Class I</b>	1 (base)			
<b>Class II/1</b>	0.88	0.244	0.72	1.08

<b>Class II/2</b>	0.85	0.193	0.67	1.08
<b>Class III</b>	0.83	0.074	0.67	1.01
<b>IOTN</b>				
<b>4</b>	1 (base)			
<b>5</b>	1.05	0.37	0.93	1.18
<b>Extraction</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.16	0.01	1.02	1.32
<b>Quadhelix</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.14	0.129	0.96	1.37
<b>Functional</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.14	0.148	0.95	1.38
<b>Headgear</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.08	0.31	0.92	1.26
<b>Expose and bond/traction of ectopic maxillary canine</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.4	0.027	1.03	1.88

IRR = Incidence-rate ratio.

#### **Factors affecting the treatment duration:**

All the variables had statistically significant effects on the treatment duration. Males were associated with reduced treatment durations when compared to females (IRR=0.95).

Similarly, class II and class III malocclusions were associated with reduction in treatment time compared to class I. On the other hand, patients who had IOTN 5 and those who had extractions were associated with increase in treatment time. Treatment by headgear, quadhelix, functional appliance or expose and bond of ectopic maxillary canine was associated with increased treatment duration (Table 6).

<b>Treatment duration</b>	<b>IRR</b>	<b>P</b>	<b>[95% Conf. Interval]</b>	
<b>Sex</b>				
<b>F</b>	1 (base)			
<b>M</b>	0.95	0.00	0.93	0.97

<b>Malocclusion</b>				
<b>Class I</b>	1 (base)			
<b>Class II/1</b>	0.95	0.00	0.92	0.98
<b>Class II/2</b>	0.87	0.00	0.84	0.91
<b>Class III</b>	0.92	0.00	0.89	0.95
<b>IOTN</b>				
<b>4</b>	1 (base)			
<b>5</b>	1.1	0.00	1.08	1.124
<b>Extraction</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.15	0.00	1.13	1.18
<b>Quadhelix</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.08	0.00	1.05	1.11
<b>Functional</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.22	0.00	1.18	1.26
<b>Headgear</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.12	0.00	1.09	1.15
<b>Expose and bond/traction of ectopic maxillary canine</b>				
<b>No</b>	1 (base)			
<b>Yes</b>	1.46	0.00	1.39	1.53

IRR = Incidence-rate ratio.

**The effect of broken, rescheduled and emergency appointments on Treatment duration:**

There was a significant effect on the treatment duration with increased number of broken, rescheduled and emergency appointments. However, increased number of missed appointments during treatment was associated with an increase in the treatment duration while a reduced number of emergency appointments was shown to increase treatment time (Table 7).

<b>Treatment duration</b>	<b>IRR</b>	<b>P</b>	<b>[95% Conf. Interval]</b>	
<b>Number of broken/rescheduled appointments</b>	1.03	0.00	1.031	1.034
<b>Number of Emergency appointments</b>	0.98	0.00	0.97	0.98

Incidence-rate ratio (IRR).



## Discussion

The intent of this study was to evaluate the efficiency and effectiveness of Orthodontic treatment in the NHS hospitals and to identify factors that may be predictive of the duration of Orthodontic treatment and number of patients' visits.

Intra-examiner reliability was described by the correlation between the difference and mean of the first and second PAR scores, and further analysed by Pearson correlation coefficients.

Agreement between the 1st and 2nd measurements was analysed with Bland-Altman plots (Bland and Altman 1986) by using 95% limits of agreement. The intra-examiner agreement was high (>0.99) demonstrating a high level of reliability.

The records of 70 of patients, whose orthodontic treatment have been completed and have started the retention regimen, were randomly collected from Guy's hospital and King's college hospital. In order to reduce selection bias, around 30% of the patients' records were collected from 3rd year students who just finished the treatment and another 30% were collected from the consultants' clinics. Those are usually patients that the consultants complete their retainer review appointments after the 3rd year students have finished their training. The remaining patients were selected from the lab diary where appointments for removing the fixed appliances and fitting retainers were made. This was done as bias may be introduced when only cases with better results are introduced for evaluation.

A greater proportion of the patients were females (61.4%), with average age of 12 years and 9 months where, only 7% of the patients were adults (> 20 years old). With regards to the initial malocclusion, this sample showed that class II/1 and class III malocclusions were more common (38.5% and 40% respectively). Approximately 12.8% of the cases were class II/2 and only 8.5% had class I malocclusion.

Regarding the treatment characteristics, around half of the patients (47%) had extractions as a part of their orthodontic treatment. 11.4% were treated with functional appliances (Twin block), 17% had headgears whether to support anchorage or for distalization of the first

molars and 10% were treated with quadhelixes. Even though 12 patients with unerupted upper canines were identified, only 2 adolescent patients required surgical exposure with traction of the impacted canine as a part of the orthodontic treatment.

**Retention regimen and duration:**

The most common retention regimen in this investigation was found to be upper and lower Essix retainers accounting for 38.5% of the cases followed by upper and lower Hawley retainers (25.7%) and upper Hawley with lower Essix retainers (17%). The increased use of Essix retainers especially in the lower arch can be explained by the available evidence. In 2007, a randomized clinical trial showed significantly greater changes in irregularity of the incisors in the Hawley group than in the VFR group at 6 months. The differences were 0.56 mm in the mandibular arch and 0.25 mm in the maxillary arch (Rowland et al. 2007). VFRs were also found to be more cost-effective than Hawley retainers and patients showed a preference for them (Hichens et al. 2007).

In this study, retention duration was measured from the “date of end of treatment/beginning of retention” till the “date of discharge/last review”, where, the retention duration was found to be an average of 10 months (307 days) with 2 review appointments during this period. According to a survey carried out in the UK in 1997, the most commonly used retention period was 12 months (Clark et al. 1997). In general, at present there are insufficient research data on which to base our clinical practice on retention (Littlewood et al. 2006).

**Number of operators:**

In this sample, only 14% were treated by 2 operators whereas around 85% were treated by 1 operator. McGuinness and McDonald (1998) found that the change of operator can prolong the treatment duration but there was no correlation between the length of treatment time and the final standard of orthodontic treatment result as measured by the PAR score. The authors recommended that patients who are treated by orthodontic postgraduate students



should, if possible, have their treatment completed by the same student. Accordingly, it might be beneficial, in terms of treatment duration, to try to aim to treating patients in NHS hospitals by one operator only.

**Treatment need:**

From the data of this study, it was shown that 98.5% of the patients treated with fixed appliances in both hospitals were in definite need for treatment on dental health grounds where, 61% of those patients were IOTN 4 and 38% were IOTN 5. Compared with 87% in the hospital service in a study in 1993 (O'Brien et al. 1993) , it is noted that patient selection has changed in terms of more severe malocclusions being selected for treatment in NHS hospitals.

**Treatment outcome:**

The mean percentage PAR score reduction in this study was 81.5% with only 1.4 % of cases falling into the 'Worse or no different' category, which represents a high standard of treatment. This result is an improvement compared to other studies. In one study on orthodontics in the hospital service, 75.5% reduction in PAR scores was found when two-arch fixed appliance therapy was used in 17 hospitals in England and Wales (O'Brien et al. 1993). In another retrospective study in 1999, the mean percentage PAR score reduction was 71.7% in patients treated with upper and lower fixed appliances (Turbill et al. 1999). However, due to the large sample size in the previous two studies, we should be cautious about drawing conclusions compared to this one. The high standard of treatment may be partly due to the fact that all the patients in this study were treated by fixed appliances which was found to have the greatest influence on the treatment outcome (Richmond et al. 1993).

One drawback about selecting completed cases in this investigation is that discontinued cases are not included in the study sample. One of the greatest risks of orthodontic

treatment is failure to complete treatment. Accordingly, the rate of discontinuation should be evaluated when assessing the treatment outcome (Shaw et al. 1991).

The outcome of orthodontic treatment in patients treated with extractions was compared to that of patients treated without extractions using the PAR index. We found no statistical difference between the 2 groups in terms of PAR score reduction. Our findings agree with Holman et al (1998), who found that both the extraction and non-extraction groups were statistically identical at the end of treatment in terms of percentage reduction in PAR scores.

**Treatment duration, waiting time for treatment and number of appointments:**

In the context of this study, the waiting time for treatment was measured from “The date of diagnosis” which was defined as the date the patient was placed on the waiting list for orthodontic treatment till “The date of beginning of Orthodontic treatment” which is the date the patient was booked with the operator for treatment. The mean duration the patients were on the waiting list for treatment was around 4.4 months.

Treatment duration was measured from the beginning till the end of Orthodontic treatment, where, the end of treatment was defined as the date of removal of the fixed appliances and beginning of retention regimen. In this study, the mean treatment duration was 27 months with an average of 21 appointments during treatment. This treatment time is much longer than the 13 months treatment duration that was suggested earlier by Turbill et al in cases completed in National Health Service practices in England and Wales (Turbill et al. 2001).

We tried to identify factors that may be predictive of the duration of Orthodontic treatment and number of patients’ visits. With regards to treatment duration, factors found to increase duration were female patients, great treatment need (IOTN 5), extractions, using headgears or Quadhelixes, functional appliances in conjunction with the fixed appliances and surgical exposure and bond of ectopic maxillary canines.

Variables such as gender, malocclusion and IOTN have been reported to affect treatment duration where, class II division 1 and class II division 2 malocclusions and female patients

were linked to lengthening the treatment time (Taylor et al. 1996; Vig et al. 1998). We had similar findings with regards to gender but Class II and class III malocclusions were associated with reduction in treatment time compared to class I. However, in previous studies they were classifying malocclusion according to the molar relationship unlike this study where we used the incisor classification.

An increase in duration with starting IOTN of grade 5 was found in a previous study (Turbill et al. 2001), which confirms what we found in this investigation.

Our findings concerning extractions concur with others (Vig et al. 1990; Fink and Smith 1992; Turbill et al. 2001). This may be due to that extractions tend to be associated with treatment of more severe discrepancies and that treating cases without extractions avoids the need for closure of residual spaces. Fink and Smith (1992) 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.

Our findings also parallel others in that headgear wear is linked to longer treatment duration (Beckwith et al. 1999; Turbill et al. 2001). Beckwith et al (1999) found that headgear wear had a statistically significant ( $P = 0.014$ ) correlation with treatment time and that if headgear was prescribed during treatment, the estimated time in treatment was 3.66 months longer than if no headgear was worn.

Using a removable functional appliance or a quadhelix usually entails having two stages of orthodontic treatment and this was shown to significantly increase the treatment duration in this study. Multiple treatment stages have been linked to longer duration in other studies as well (Vig et al. 1990; Beckwith et al. 1999; Turbill et al. 2001).

We also tried to identify the variables which would influence the number of scheduled appointments during treatment. The results of this study showed that treatment involving

extractions was the only variable associated with increased number of appointments. There were no studies with which the present results could be compared.

### **Effect of broken/rescheduled appointments and emergency appointments on treatment**

#### **duration:**

The findings in the present investigation support the observations made by Beckwith et al (1999) that missed appointments exhibited a statistically significant correlation with treatment time. They also found in their study that each failed appointment was associated with a little over 1 month additional estimated time in treatment. Missed appointments may be considered as a measure of overall patient compliance as patients with missed appointments are more likely to exhibit other forms of noncompliance, such as lack of headgear or elastics wear, and increased appliance breakage.

On the other hand, in this investigation we found that reduced number of emergency appointments was shown to increase treatment time. This may be explained by the fact that the orthodontist would use the scheduled appointment to deal with the patient's problem instead of proceeding with the orthodontic treatment which would not be the case if the patient showed earlier for an emergency appointment.

#### **Limitations:**

The small number of patients who fell into certain categories, such as adults and patients with impacted canines that were surgically exposed, patients who were treated with removable appliances or rapid maxillary expansion, limited the predictive ability of examining these variables. Sample size couldn't be increased due to the limited number of study models that could be collected from Guy's hospital for this study. This was due to the recent change in the storage system where all study models were scanned and discarded. For the sake of standardisation and due to the lack of evidence at this stage that PAR scoring of scanned study models was accurate, we didn't use the scanned study models.

Many other variables could have been examined that have the potential to influence orthodontic treatment duration and the number of appointments during treatment such as the individual features of malocclusion or tooth movements.

## **Conclusions**

Based on the results of this study, the following conclusions may be drawn:

- 1- 98.5% of the patients treated with fixed appliances in both hospitals were in definite need for treatment on dental health grounds.
- 2- The mean percentage PAR score reduction was 81.5% with only 1.4 % of cases falling into the 'Worse or no different' category from the PAR normogram.
- 3- The mean duration the patients were on the waiting list for treatment was around 4.4 months, the mean treatment duration was 27 months with an average of 21 appointments during treatment.
- 4- Factors increasing treatment duration included:
  - Female patients, Class I malocclusions, IOTN 5, treatment involving extractions, prescribing headgear wear during orthodontic treatment, the use of functional appliances or Quadhelixes.
  - Increased number of missed appointments.
- 5- Factors reducing the treatment time were male patients, class II or class III malocclusions and an increased number of emergency appointments.

**Authors and contributors:**

## References

- Ackerman M. 2004. Evidence-based orthodontics for the 21st century. *J Am Dent Assoc.* 135(2): 162-167.
- Beckwith FR, Ackerman RJ, Cobb CM, Tira DE. 1999. An evaluation of factors affecting duration of orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 115:439-447.
- Bland JM, Altman DG. 1986. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 327:307-310.
- Brook PH, Shaw WC. 1989. The development of an index of orthodontic treatment priority. *Eur J Orthod.* 11:309-320.
- Clark JD, Kerr WJ, Davis MH. 1997. CASES--clinical audit; scenarios for evaluation and study. *Br Dent J.* 183:108-111.
- DeGuzman L, Bahiraei D, Vig, KW, Vig PS, Weyant, RJ, O'brien, K. 1995. The validation of the Peer Assessment Rating index for malocclusion severity and treatment difficulty. *Am J Orthod Dentofacial Orthop.* 107:172-176.
- Fink DF, Smith, RJ. 1992. The duration of orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 102:45-51.
- Hichens L, Rowland H, Williams A, Hollinghurst S, Ewings P, Clark S, Ireland A, Sandy J. 2007. Cost-effectiveness and patient satisfaction: Hawley and vacuum-formed retainers. *Eur J Orthod.* 29:372-378.
- Holman JK, Hans MG, Nelson S, Powers MP. 1998. An assessment of extraction versus nonextraction orthodontic treatment using the peer assessment rating (PAR) index. *Angle Orthod.* 68:527-534.
- Kelly BM, Springate SD. 1996. Specialist orthodontics in the general dental service. *Br Dent J.* 180:209-215.
- Linder-Aronson S. 1974. Orthodontics in the Swedish Public Dental Health Service. *Trans Eur Orthod Soc.* 233-240.

Littlewood, S. J., Millett, D. T., Doubleday, B., Bearn, D. R. and Worthington, H. V. (2006). Retention procedures for stabilising tooth position after treatment with orthodontic braces. *Cochrane Database Syst Rev*.

Lundström A. 1977. Need for treatment in cases of malocclusion. *Trans Eur Orthod Soc*. 53:111-123.

McGuinness N J, McDonald JP. 1998. The influence of operator changes on orthodontic treatment times and results in a postgraduate teaching environment. *Eur J Orthod*. 20:159-167.

O'Brien KD, Shaw WC, Roberts CT. 1993. The use of occlusal indices in assessing the provision of orthodontic treatment by the hospital orthodontic service of England and Wales. *Br J Orthod*. 20:25-35.

Parbatani R, Williams AC, Ireland AJ, Sandy JR. 2010. The process of orthognathic care in an NHS region. *Ann R Coll Surg Engl*. 92:34-39.

Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD, Roberts CT, Andrews M. 1992a. The development of the PAR Index (Peer Assessment Rating): reliability and validity. *Eur J Orthod*. 14:125-139.

Richmond S, Shaw WC, Stephens CD, Webb WG, Roberts CT, Andrews M. 1993. Orthodontics in the general dental service of England and Wales: a critical assessment of standards. *Br Dent J*. 174:315-329.

Rowland H, Hichens L, Williams A, Hills D, Killingback, N, Ewings P, Clark S, Ireland A J, Sandy JR. 2007. The effectiveness of Hawley and vacuum-formed retainers: a single-center randomized controlled trial. *Am J Orthod Dentofacial Orthop*. 132:730-737.

Salzmann JA. 1968. Handicapping malocclusion assessment to establish treatment priority. *Am J Orthod*. 54:749-765.

Shaw WC, Richmond S, O'Brien KD, Brook P, Stephens CD. 1991. Quality control in orthodontics: indices of treatment need and treatment standards. *Br Dent J*. 170:107-112.

Stolzenberg J. 1935. The Russell attachment and its improved advantages. *International Journal of Orthodontia and Dentistry for Children*. 21:837-840.

Summers CJ. 1971. The occlusal index: a system for identifying and scoring occlusal disorders. *Am J Orthod*. 59:552-567.

Taylor PJ, Kerr WJ, McColl JH. 1996. Factors associated with the standard and duration of orthodontic treatment. *Br J Orthod*. 23:335-341.

Templeton KM, Powell R, Moore MB, Williams AC, Sandy JR. 2006. Are the Peer Assessment Rating Index and the Index of Treatment Complexity, Outcome, and Need suitable measures for orthognathic outcomes?. *Eur J Orthod*. 28:462-466.

Turbill EA, Richmond S, Wright JL. 1999. Orthodontics: A closer look at General Dental Service orthodontics in England and Wales I: Factors influencing effectiveness. *Br Dent J*. 187:211-216.

Turbill EA, Richmond S, Wright JL. 2001. The time-factor in orthodontics: What influences the duration of treatments in National Health Service practices?. *Community Dent Oral Epidemiol*. 29:62-72.

Vig KW, Weyant R, Vayda D, O'Brien K, Bennett, E. 1998. Orthodontic process and outcome: efficacy studies--strategies for developing process and outcome measures: a new era in orthodontics. *Clin Orthod Res*. 1:147-155.

Vig PS, Orth D, Weintraub JA, Brown C, Kowalski CJ. 1990. The duration of orthodontic treatment with and without extractions: a pilot study of five selected practices. *Am J Orthod Dentofacial Orthop*. 97:45-51.