A closer look at General Dental Service orthodontics in England and Wales
I: Factors influencing effectiveness

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Objective To evaluate factors influencing effectiveness in General Dental Service (GDS) orthodontics.
Design Retrospective analysis of systematic 2% sample of GDS (England and Wales) cases.
Method Records of cases were collected during 1991. Assessment involved occlusal indices and data from National Health Service forms for 1,411 cases. Multivariate analyses were used with Peer Assessment Rating Index (PAR) score at Finish as the outcome indicator.
Results *Dual arch fixed appliances:* achieved lower Finish PAR scores than other appliances; only 1.5% of the variance was explained, by treatment time and Dental Health Component of the Index of Orthodontic Treatment Need (DHC). Finish PAR was unaffected by Starting PAR.
All other appliances: the model explained 25% of the variance for Finish PAR, which varied with Starting PAR and DHC scores. Social class had effects of little clinical significance, but the data suggested availability of orthodontic treatment was poorer in 'manual class' areas. Orthodontic qualifications, number of arches treated and mixed dentition starts had no significant effects when submitted to multivariate analysis.
Conclusions The importance of appliance selection is reinforced: dual arch fixed appliances are generally more consistent. Lower social class areas may be poorly provided with orthodontic services.

The effectiveness of orthodontic treatment, particularly that undertaken in the General Dental Services (GDS), became a focus of interest after media coverage in the mid-1980s, and the subsequent 'Schanschieff Report'.[1] Several studies have shown that appliance type is a predominant factor in orthodontic treatment outcome: treatments involving two-arch fixed appliances being the most, and removable appliance treatments generally the least effective.[2–7] However, it has been suggested that removable appliances can be used to good effect for certain traits of malocclusion, and that criticism should be re-directed to the factors which lead to their improper use.[8] Other factors initially linked to better outcomes were higher fees and prior approval regulations.[4] We have since shown that the relaxation of prior approval and fee changes of the late 1980s did not substantially alter standards or increase levels of over-prescription, although the partial relaxation in prior approval of 1987 was contemporaneous with a modest increase in the use of fixed appliances.[7] In the hospital service, grade of operator and individual departments were also shown to influence outcome.[6] Previous studies in GDS orthodontics demonstrated that orthodontic qualification of the operator did not in itself affect outcome,[4,7] but a more recent, albeit localised study, suggested it did have a positive effect.[9] High levels of malocclusion and need for treatment at start have, however, been shown to be linked to higher reductions and percentage reductions in PAR, but also to higher residual PAR scores.[10]

Other factors which have been linked to poorer results are high caseload,[1,11] and mixed dentition treatments.[1] In addition, social inequality has been reported variously as likely to have some influence on uptake and referral, such that patients from 'lower' social strata are less likely to receive orthodontic treatment,[12–14] or not.[15,16] There is also anecdotal evidence that some practitioners may use 'prescription by postcode' in that they are more likely to prescribe compromise treatments to patients from 'lower class' areas. Apart from a study on the effects of caseload,[10] the relative importance of these factors in orthodontic outcome has not yet been fully evaluated on a national scale in the United Kingdom.

The PAR (Peer Assessment Rating) Index and IOTN (Index of Orthodontic Treatment Need) and their development have been covered extensively in the literature.[17–19] They will not be described further here, other than to say that IOTN assesses the need for treatment according to its Dental Health Component (DHC) and/or its Aesthetic Component (AC), whereas PAR gives a single summary score representing the deviation from ideal occlusion, or the degree of malocclusion present.

The purpose of this study was, in part, to provide an overview of GDS orthodontics since the 1987–88 study.[4,5] More specifically, it was to elucidate further the possible effects of factors concerning patients and practitioners, in particular the effects of social inequality, and of the treatment itself on the entry and exit levels of malocclusion in GDS orthodontics.

Methods

The Dental Practice Board of England and Wales (DPB) were asked to collect 1,500 consecutive cases from their routine systematic sample: records are requested for every 50th completed case presenting for payment.[20] (This sampling system was set up by the Data Services Department at the DPB, and forms the basis of the DPB's Annual Report on Orthodontics.) The study casts were scored using PAR and IOTN by one of the authors (ET), who is calibrated in the use of the indices, and relevant information was recorded from the National Health Service FP17(O) form submitted for each case, concerning the patients and their practitioners, including postcodes,

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whether the practitioner was orthodontically qualified, appliance sequence and whether the treatment was started in the mixed or permanent dentition. (All names and addresses had been obliterated to respect confidentiality.)

After preliminary exploration of the data and logarithmic conversions to improve normality of distribution where necessary, analysis of covariance was used to attempt to find linear models for PAR score at finish (FPAR), and ANOVA for PAR score at start (SPAR), using the *SPSS for Windows package*:[21] P(in) ≤ 0.05 and P(out) > 0.1. Factors were submitted and removed experimentally to find the best fitting model in each case. Factors considered in all the analyses were:

- Caseload of the operator (high-earning orthodontists or others[10])
- Whether the practitioner held a diploma/membership in orthodontics/dental orthopaedics
- Social class of the patients' neighbourhoods and practice areas (higher or lower 50th percentile of manual workers),
- Developmental status of dentition at start: Mixed, permanent or (in a few cases) chartings absent,
- Age band at start (under 11, 11 and over but under 16, 16 years and over),
- Prior approval or fee band under which treatment was started.[7]

A further four variables were submitted to the analyses for PAR data at finish only:

- Starting PAR score (SPAR) or its logarithm (base 10), as co-variate
- DHC and AC grades at start
- Number of arches treated
- Appliance regime used (ie treatments involving use of dual arch fixed appliances, those including use of a single arch fixed appliance, and removable/myofunctional/other treatments)
- Length of time in treatment.

The Mann-Whitney U test was used to compare ordinal variables, such as AC and DHC grades, and the chi-squared test to compare proportions of cases in various categories.

Definition of social class areas

Information on social class of the patients' neighbourhoods and practice areas was obtained from the postcodes, using SASPAC software,[22] which allows interrogation of the 1991 census data. Data available included the numbers of the Registrar General's five social classes living in a 10% sample of households in each ward. The distributions of 'manual class' (Social Classes IIIM, IV and V) households and their 50th percentile were determined for England and Wales and used as the 'cut-off' to define areas represented in the sample as falling in the 'Less-' or 'More manual households' half of wards nationally.

Results

A total of 1,527 consecutively requested cases were collected; 98% of the treatments were completed between June 1990 and September 1991. The postcodes on a few FP17(O)s were absent or incomplete.

Social class of patients' homes and practitioners' practice areas

A total of 1,482 cases had social class data available for the patients' home, and 1,452 for the practice areas, and the distributions of social class strata for both are shown in Table 1, along with the distribution for all wards in England and Wales. A preponderance of patients were from 'less manual' (ie 'more middle class') areas compared to the national distribution (chi-squared = 14.44, df = 1; $P < 0.00001$), similarly, the practices tended more frequently to be in these areas (chi-squared = 16.31, df = 1, $P < 0.000005$).

Other patient and practitioner characteristics

The arithmetic mean age at start of treatment was 12.7 years (SD = 2.6; 5th–95th percentiles: 8.8–16.2 years).

Numbers of cases treated by practitioners with post-graduate qualifications in orthodontics, and by those in the DPB's 'High earners from orthodontics' category have been described previously.[10]

Treatment characteristics

Of the treatments, 25% involved dual arch fixed, 26% involved single arch fixed and 49% involved only removable or 'other' appliance regimes. Only 1% of cases involved use of myofunctional appliances, so these were not analysed separately.

Thirty per cent of the treatments involved appliances to both arches, and this included 2% of those treated only with removable

Table 1 Distribution of 'more-' and 'less-manual class' household wards:* nationally and among patient and practice addresses in sample

Area type	England and Wales		Patients' homes		Practice areas	
	No.	Percentage	No.	Percentage	No.	Percentage
Less manual half†	4,672	49.9%	852	57.4%	852	58.7%
More manual half‡	4,691	50.1%	630	42.6%	600	41.3%
Total wards recorded	9,363		1,482		1,452	

*Based on percentages of manual class heads of households (Registrar General's Social Classes IIIM, IV and V) in all wards in England and Wales
†Less than or equal to 50th percentile of manual class heads of households

Table 2 Levels of orthodontic need for treatment at start of treatment for the 1991 General Dental Services sample — assessed using the Aesthetic and Dental Health Components of the Index of Orthodontic Treatment Need (IOTN)

Table 2a: Descriptive statistics for IOTN grades	Aesthetic Component (AC)	Dental Health Component (DHC)
Median grade	8	4
5th–95th percentiles	4–10	3–5

Table 2b: Frequencies of cases in need categories	Aesthetic need		Dental health need	
	Cases	Percentage	Cases	Percentage
Clear need (AC grades 8–10; DHC grades 4 & 5)	764	50.0%	1,225	80.2%
Borderline (AC grades 5–7; DHC grade 3)	685	44.9%	291	19.1%
No/little (AC grades1–4; DHC grade 1 & 2)	78	5.1%	11	0.7%
Low overall objective need (cases with DHC grade ≤ 3 and AC grade ≤ 4)	43 (2.8%) cases			

appliances, and 16% of cases whose treatment involved use of a fixed appliance in one arch. At least 506 (33%) cases were started in the mixed dentition, 822 (54%) in the permanent dentition; for the others the chartings were not complete.

The (arithmetic) mean treatment time was 1.3 years (SD = 0.8; 5th–95th percentiles: 0.3–2.7 years).

Need for treatment at start

The descriptive data for AC and DHC grades are shown in Table 2, along with the distribution of need categories (no/little, borderline or clear) under the two components.

All the various sub-groups of practitioners treated a similar spectrum of need, although as described previously, 'high-earning' orthodontists tended to treat slightly more cases toward the lower end of the need spectrum, but these differences were too small to be of clinical significance.[10]

Cases with low overall objective need (or 'unnecessary' treatments: DHC ≤ 3 and AC ≤ 4 at start) had an overall incidence of 2.8%, with no differences between any sub-groups ($P > 0.1$).

Malocclusions at start and finish of treatment

The PAR data descriptives for the whole 1990–91 GDS sample are shown in Table 3. A one-way ANOVA test showed significant differences between Finish PAR for all three appliance regimes ($F_{2.1408} = 108.88$, $P < 0.00005$).

The multivariate analyses

A total of 1,411 cases had full social class data available on both patients' home and practice areas, and these were submitted to the multivariate analysis.

Levels of malocclusion at start — Start PAR score (SPAR)

The best model found explained only 1.5% of the variance. Permanent dentition and higher social class patients' neighbourhoods were associated with treatment of patients with slightly lower SPAR scores, but only with differences in group means of 2 PAR points or less.

Levels of malocclusion at finish — Finish PAR score (FPAR)

Whereas the regression lines for Log_{10} Finish PAR (LogFPAR) for both the single arch fixed and the removable/other appliances only groups varied with LogSPAR, that for the dual arch fixed group showed no relationship with LogSPAR (fig. 1). For clarity of interpretation, we investigated these two appliance groups separately, rather than including them in one model.

The models presented in both cases are for LogFPAR only. Although treatment standards are commonly described in terms of reductions, or percentage reductions in PAR, it has been suggested that improvement measures are less sensitive than simple post-treatment scores, as they increase the amount of error in the analyses.[23]

Regression for single arch fixed and removable/other appliance treatments

Log_{10} Finish PAR score (LogFPAR) (see Table 4). The model for this had LogSPAR as the co-variate and explained 25% of the variance. Removable appliances, DHC grades 4 and 5 at start, and to a much lesser extent, practices in more 'manual class' areas, were associated with higher FPAR scores.

Dual arch fixed appliances

Log_{10} Finish PAR (Table 5) did not vary with SPAR or its logarithm. It varied inversely with time ($0.05 < P < 0.1$); longer dual arch fixed treatments tended to reduce PAR to lower levels. DHC at start was included in the model and varied with LogFPAR, but with less than 2 PAR points between all group means ($0.05 < P < 0.1$). The model explained only 1.5% of the variation.

Discussion

Overall standards of orthodontic treatment in this GDS sample were comparable with those reported in the 1987–88 GDS study,[4,5] although use of fixed appliance treatments had increased, and levels of residual malocclusion had fallen marginally; this has been reported and discussed in detail previously.[7]

There was considerable variation within the sample, but treatment

Table 3 Peer Assessment Rating (PAR) Index descriptives for the 1991 General Dental Services orthodontic sample

	Arithmetic mean	SD	Geometric mean* (to centre skewed data)
Data for whole sample			
Start PAR score	26.94	10.26	–
Finish PAR score	12.79	7.38	10.72
PAR reduction	14.16	10.77	–
Percentage reduction	47.59%	33.43	56.23%
Removable appliance only/other treatments			
Start PAR score	26.74	9.55	–
Finish PAR score	15.19	7.65	13.35
PAR reduction	11.56	10.78	–
Percentage reduction	39.08%	33.16	46.35%
Treatments including a fixed appliance on one arch ('single arch fixed')			
Start PAR score	24.74	10.53	–
Finish PAR score	11.40	6.52	9.51
PAR reduction	13.20	9.87	–
Percentage reduction	49.11%	32.75	57.26%
Treatments including use of fixed appliances on both arches ('dual arch fixed')			
Starting PAR score	29.69	10.76	–
Finish PAR score	9.36	5.80	7.85
PAR reduction	20.27	8.56	–
Percentage reduction	63.26%	28.53	71.79%

*Antilog of mean logarithm (base 10) of scores

Table 4 Single arch fixed and removable/other appliance regimes: analysis of covariance for Log_{10} Finish Peer Assessment Rating (PAR) score (forward, stepwise insertion of variables and factors (P_{in} = 0.05, P_{out} = 0.1))

Variable	Sums of Squares	Degrees of freedom	Mean squares	F-value	Probability
Residual	52.00	1,056	0.05		
Log Start PAR (co-variate)	7.74	1	7.75	157.41	< 0.0005
? Fixed appliance used	3.52	1	3.52	71.40	< 0.0005
DHC* grade at start	0.66	2	0.33	6.67	= 0.001
Practice area	0.52	1	0.52	0.64	= 0.001
Total	70.01	1,061	0.07		

Adjusted R^2 0.245

Group geometric mean values of Finish PAR score, allowing for covariance

	Mean log	Geometric mean	Number in group	Tukey group†(P < 0.05)
Appliances used:				Appliance used
Removable only	1.12545	13.35	695	A
Single arch fixed	0.97818	9.51	367	B
DHC* grade:				DHC grade
3 or less	0.94272	8.76	202	A
4	1.08240	12.09	674	B
5	1.18930	15.46	186	C
Social class of practice area:				Social class of practice
Less manual half	1.04538	11.10	591	A
More manual half	1.11115	12.91	471	B

*Dental Health Component of the Index of Orthodontic Treatment Need
†Different letters indicate sub-groups within headings are different at $P < 0.05$ level

Table 5 Dual arch fixed appliance regimes: analysis of covariance for Log_{10} Finish Peer Assessment Rating (PAR) score (forward, stepwise insertion of variables and factors (P_{in} = 0.05; P_{out} = 0.1))

Variable	Sums of squares	Degrees of freedom	Mean squares	F-value	Probability
Residual	25.12	345	0.07		
Time in treatment (co-variate)	0.24	1	0.24	3.30	= 0.070
DHC* grade at start	0.35	2	0.18	2.41	= 0.091
Total	25.72	348	0.07		

Adjusted R^2 0.015

Group geometric mean values of Finish PAR, allowing for covariance

	Mean log	Geometric mean	Cases in group	Tukey group (P < 0.05)
DHC* grade:				
3 or less	0.90879	8.15	78	No differences between
4	0.86848	7.39	214	groups at P < 0.05 level
5	0.95496	9.02	57	

* Dental Health Component of the Index of Orthodontic Treatment Need

standards were overall poorer than those shown by a more recent study in the North West of England,[9] although as that was prospective in design, as well as being localised and dependent upon the consent of the participating practitioners, one should be cautious about drawing firm conclusions from comparisons between the two studies.

Social class and the patient sample

The distribution of social class spectra in the patients' home and practice areas (Table 1) suggests that there may be some inequality in uptake and provision of orthodontics under the GDS. Regarding patients' home areas, it is difficult to be sure how far social class *per se* influences receipt of treatment by patients, rather than differences in levels of oral care[14,24] or concern with dental appearance[12,14,15] between different social strata. The small differences in entry and exit levels of malocclusion seen between the social strata in this sample (≤ 2 PAR points, see later) suggest no real disadvantage to the patients from 'lower class' areas who received treatment. However it has been shown that greater availability of dental treatment increases uptake among the lower social classes,[25] thus it was argued that their attitudes to treatment may reflect availability rather than inherently different attitudes.[26] Pavi *et al.*[24] suggested that while the middle classes are often prepared to travel to see a particular practitioner, the lower classes tend simply to use whatever services are available in their area. This would certainly be consistent with the preponderance of more middle class home areas seen in this sample, and so the distribution of practices may well represent a disadvantage to children and teenagers in lower social class areas. This may warrant further research to evaluate it fully, and to find to what extent

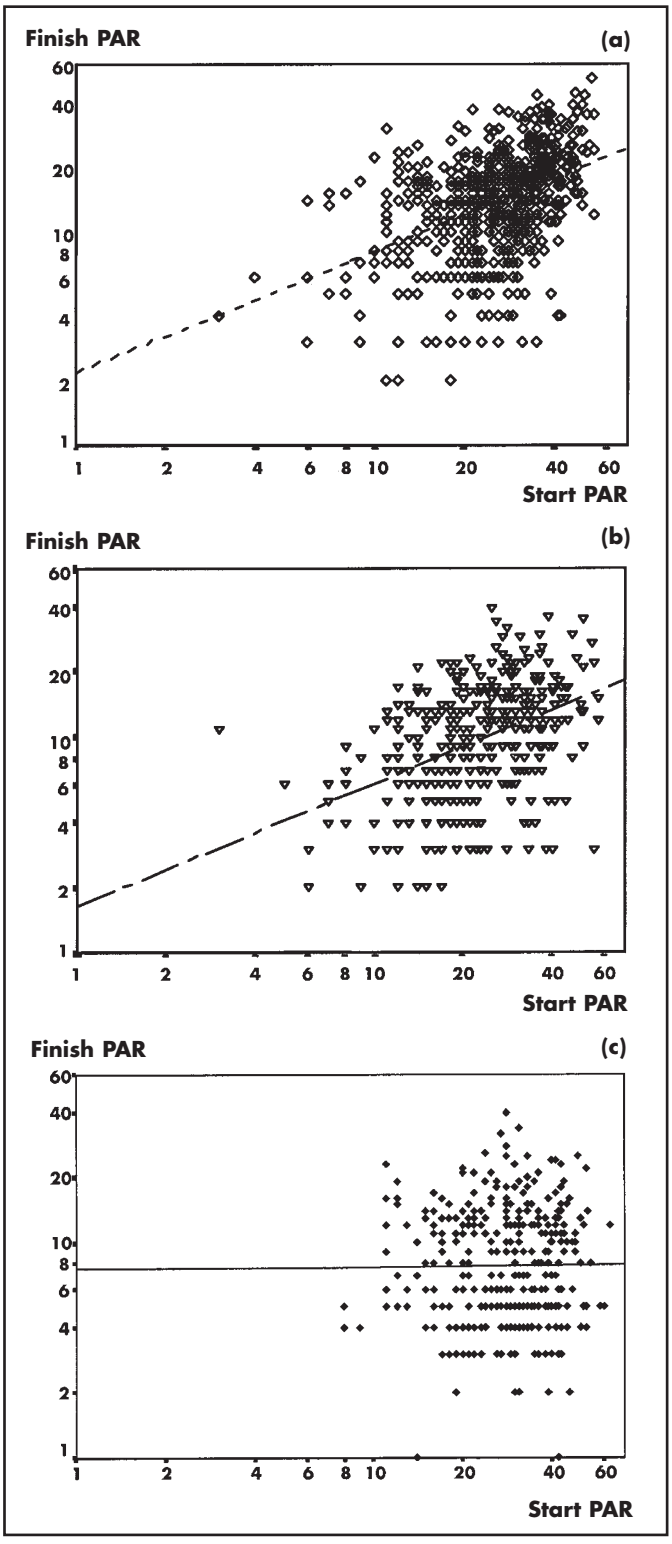

Fig. 1 Variation of Peer Assessment Rating Index score at finish (Finish PAR) with PAR score at start of treatment (Start PAR) — axes drawn to logarithmic scale: (a) removable/other appliance only treatments, (b) single arch fixed appliances used in treatment, (c) dual arch fixed appliances

the salaried services, perhaps particularly the Community Orthodontic Service, make good this apparent shortfall.

Levels of malocclusion at start

The mean Start PAR values suggest that, generally, cases accepted for treatment in the GDS exhibit a substantial degree of malocclusion. However, the variance in levels of malocclusion at start was largely unexplained by our analysis, suggesting that there was no particular pattern to the degrees of malocclusion across the parameters, or that variables not available to us were important. Small differences were seen in mean SPAR between mixed and permanent dentition starts and between patients from neighbourhoods of different social strata, although none of these differences could really be considered *clinically* significant (≤2 PAR points in all cases).

Levels of malocclusion after treatment

Appliance selection is further emphasised as an important factor in terms of both residual malocclusion and degree of improvement. The fact that LogFPAR for dual arch fixed cases did not vary with LogSPAR (fig. 1), and the data shown in Tables 3–5, emphasise that these appliances tend to reduce malocclusion to similar, relatively low levels, with less influence from other variables. Consequently, the size of their PAR Reduction is largely dependent on their Start PAR scores alone. Treatments involving use of single arch fixed appliances, although giving slightly better results than removable only/other treatments, are like them, more prone to other influences and thus less predictable, at least when used in the GDS.

Although it has been suggested that PAR favours fixed appliance treatments,[8] there is no reason why a carefully chosen removable appliance case can not show well both on its residual (FPAR) score and PAR reduction/percentage reduction; the problem undoubtedly occurs when, as has been inferred by Kerr *et al.*,[8] patients are treated with removable appliances unadvisedly. The central issue, then, is judicious and appropriate appliance selection.

The results also suggest that the interceptive treatments typically carried out in the mixed dentition are not significantly different in standard to other GDS removable appliance treatments. These treatments would be expected to predominate in cases started in the mixed dentition, or under the age of 11 years, and neither of these groups was found to be significantly different in the analysis.

The influence of SPAR and DHC scores, (Tables 4 and 5), have already been shown and discussed elsewhere.[10] They parallel earlier findings that milder malocclusions were less likely to benefit from orthodontic intervention.[4,5] While it is logical that only marked malocclusions can have large reductions in PAR, it is a shortcoming of treatment choice and/or execution, if mean FPAR scores are not similarly low regardless of such factors; the lower mean FPAR, and the lack of linear relationship between FPAR with SPAR in dual-arch fixed appliance cases is strongly suggestive of greater reliability of outcome with these treatments.

Although statistically significant effects were seen for social class of practice areas in the non-dual-arch-fixed group, these were too small to be considered of clinical significance (<2 PAR points).

What the analyses did not explain

Very little of the variance in Start PAR is explained, and there is no way of knowing how closely the sample represented all the cases presenting for treatment to various practitioners. Both the models for Finish PAR score also left much variation unexplained. O'Brien *et al.*,[6] in their study on orthodontics in the hospital service, commented on differences between individual consultants as a likely significant factor, and this could be expected to apply to individual practitioners in the GDS too. Their individual clinical abilities and aspirations would be of similar significance; in addition their judgement as to whether a case was within their capabilities, or should be referred to another practitioner or service, and the availability of referral services in their area would also be important. Another source of variability between practitioners would be their judgement as to when a case was complete. It was previously seen that mean PAR exit values of discontinued cases varied only slightly from those of completed cases,[27] perhaps suggesting that the threshold for deciding whether to claim an imperfect case as 'complete' and risk closer scrutiny from the DPB, or whether to claim it as 'discontinued' and accept a substantial fee reduction also varies between

practitioners. Individual patients' biological and personal characteristics may be another important factor, and also the personal interactions between individual practitioners and patients, but such details as these are not available in a study of this nature.

The way forward

This study could perhaps be regarded as a 'milestone marker' since the GDS (England and Wales) orthodontic study of 1987–88.[4,5] It remains to be seen whether or not the small but statistically significant changes in outcome indicators seen in the 1990–91 sample[7] represented the start of a general nationwide improvement in standards, or were a spurious observation of no real significance.

Since our data were collected, there have been several service changes for orthodontics in the GDS. Although we previously showed fees not to have affected patterns of practice during the period covered by this study,[7] it remains a possibility that more drastic changes in fees and regulations may well affect patterns of prescription and practice under the GDS. Perhaps the time is ripe for a further national study into GDS orthodontics to define standards at the dawn of the new millennium.

Another recent innovation which may elucidate how orthodontic services could be improved is the concept of Local Commissioning and the Personal Dental Services (NHS (Primary Care) Act, 1997), to tailor dental services to local needs. Several orthodontic schemes are currently being piloted, involving both the provision of, and remuneration for orthodontics. The results of some of these schemes, when they are available, may have relevance to the provision of orthodontic care nationally.

Conclusions

This study assessed a sample of cases in which overall need for treatment and levels of malocclusion at start, as well as effectiveness of the treatments, were little different to those seen previously in the 1987–88 study of GDS cases in England and Wales.[4,5] The main findings were as follows:

- Levels of malocclusion at start showed little variation between the groups studied. Two groups however had marginally lower thresholds for entry to treatment (Start PAR scores):
  - Patients in the permanent dentition, and
  - Patients from more 'middle class' areas, ie areas with fewer manual class heads of household.
- The results further elucidate the findings of earlier studies, which have shown that appliance selection has a powerful influence on the effectiveness of treatments.[4–7,10] In particular:
  - Dual arch fixed appliances are more consistent in achieving lower levels of Finish PAR, independently of Start PAR, and with less influence from other variables.
  - Finish PAR scores for non-dual-arch-fixed regimes were influenced by, and varied with, Start PAR and DHC scores, thus fewer cases achieved lower levels of malocclusion.
- Social class of practice area (non-dual-arch-fixed regimes) was associated with small differences in Finish PAR of little clinical significance. However, the data suggested that:
  - Orthodontic treatment may be less readily available in areas with a high proportion of 'manual class' heads of household, and this may be a barrier to treatment for children in such areas.
- Longer treatments (dual arch fixed) were associated with marginally lower residual malocclusion.
- Age of patient and stage of development of dentition had no significant effects on outcome.
- Number of arches treated (non-dual-arch-fixed) was not significant in the multivariate analysis.

Our findings reinforce the view that any further improvement in GDS orthodontic standards will depend on more judicious selection of appliance regimes generally, and more use of dual arch fixed appliances in particular. This may require more practitioners to refer on to others if the appropriate appliance type, or expertise, is not available within their practice, as well as arguably highlighting a need for more practitioners to be trained in fixed appliance orthodontics. There may also be a case for adjusting the fee-differential for dual arch fixed appliances to encourage their use, or for reviewing the provision and remuneration of GDS orthodontics more widely.

1 *Report of the Committee of Inquiry into Unnecessary Dental Treatment.* ('The Schanschieff Report'). London: DHSS, HMSO, 1986.
2 Jones M L. The Barry Project – a three-dimensional assessment of occlusal treatment change in a consecutively referred sample: The incisors. *Br J Orthod* 1990; **17**: 1-19.
3 Jones M L. The Barry Project – a three-dimensional assessment of occlusal treatment change in a consecutively referred sample: Crowding and arch dimensions. *Br J Orthod* 1990; **17**: 269-285.
4 Richmond S, Shaw W C, Stephens C D, Webb W G, Roberts C T, Andrews M. Orthodontics in the General Dental Service of England and Wales; a critical assessment of standards. *Br Dent J* 1993; **174**: 315-327.
5 Richmond S, Roberts C T, Andrews M. Use of the Index of Orthodontic Treatment Need (IOTN) in assessing the need for orthodontic treatment pre- and post-appliance therapy. *Br J Orthod* 1994; **21**: 175-184.
6 O'Brien K D, Shaw W C, Roberts C T. The use of occlusal indices in assessing the provision of orthodontic treatment by the hospital orthodontic services of England and Wales. *Br J Orthod* 1993; **20**: 25-35.
7 Turbill E A, Richmond S, Wright J L. A critical assessment of orthodontic standards in England and Wales (1990–1991) in relation to changes in prior approval. *Br J Orthod* 1996; **23**: 221-228.
8 Kerr W J, Buchanan I B, McColl J H. Use of the PAR Index in assessing the effectiveness of removable orthodontic appliances. *Br J Orthod* 1993; **20**: 351-357.
9 Fox N A, Richmond S, Daniels C. Factors affecting the outcome of orthodontic treatment within the General Dental services. *Br J Orthod* 1997; **24**: 217-222.
10 Turbill E A, Richmond S, Wright J L. A critical assessment of high-earning orthodontists in the General Dental Services of England and Wales (1990-1991). *Br J Orthod* 1998; **25**: 47-54.
11 Shaw W C. Improving British orthodontic services. *Br Dent J* 1983; **155**: 131-135.
12 Townsend P, Davidson N. (Editors). *Inequalities in Health.* The Black Report. Harmondsworth, Middlesex. Penguin Books Limited, 1982.
13 Jenkins P M, Feldman B S, Stirrups D. The effect of social factors on referrals for orthodontic advice and treatment. *Br J Orthod* 1984; **11**: 22-26.
14 Jenkins P M, Feldman B S, Stirrups D. The effect of social class and dental features on referrals for orthodontic advice and treatment. *Br J Orthod* 1984; **11**: 185-188.
15 Kenealy P, Frude N, Shaw W C. The effects of social class on the uptake of orthodontic treatment. *Br J Orthod* 1989; **16**: 107-111.
16 Burden D J, Mitropoulos C M, Shaw W C. Residual orthodontic treatment need in a sample of 15- and 16-year-olds. *Br Dent J* 1994; **176**: 220-224.
17 Shaw W C, Richmond S, O'Brien K D, Brook P H, Stephens C D. Quality control in orthodontics: Indices of treatment need and treatment standards. *Br Dent J* 1991; **170**: 107-112.
18 Richmond S, Shaw W C, O'Brien K D, Buchanan I B, Jones R, Stephens C D, Roberts C T, Andrews M. The development of the PAR (Peer Assessment Rating) Index: Reliability and validity. *Eur J Orthod* 1992; **14**: 125-139.
19 Richmond S, Shaw W C, Roberts C T, Andrews M. The PAR (Peer Assessment Rating) Index: Methods to determine outcome of orthodontic treatment in terms of improvement and standards. *Eur J Orthod* 1992; **14**: 180-187.
20 Hinman C. Practice Management Forum. The Dental Practice Board Orthodontics – The current status. *Br J Orthod* 1995; **22**: 287-290.
21 *SPSS for Windows 1993.* SPSS Inc., Chicago.
22 SASPAC (Small Area and Local Base Statistics). The London Research Centre.
23 Norman G R. Issues in the use of change scores in randomised trials. *J Clin Epidemiol* 1989; **42**: 1097-1105.
24 Pavi E, Kay E J, Shepherd K W. The effect of social and personal factors on the utilisation of dental services in Glasgow, Scotland. *Community Dent Health* 1995; **12**: 208-215.
25 O'Mullane D M, Robinson M E. The distribution of dentists and uptake of dental treatment by schoolchildren in England. *Community Dent Oral Epidemiol* 1977; **5**: 156-159.
26 Shaw W C, O'Brien K D, Richmond S. Quality control in orthodontics: Factors influencing the receipt of orthodontic treatment. *Br Dent J* 1991; **170**: 66-68.
27 Richmond S, Andrews M. Discontinued orthodontic treatment in the General Dental Services of England and Wales (1990-1991). *Br J Orthod* 1995; **22**: 263-268.