European Journal of Orthodontics 19 (1997) 279–288

Evaluation of treatment and post-treatment changes by the PAR Index

Kari Birkeland, Jakob Furevik, Olav Egil Bøe and Per Johan Wisth
Department of Orthodontics and Facial Orthopedics, University of Bergen, Norway

SUMMARY To assess the outcome of orthodontic treatment, 224 cases treated in a postgraduate clinic were evaluated. Pre-treatment (T_1), post-treatment (T_2) and 5-year follow-up (T_3) study casts were assessed by the Peer Assessment Rating (PAR) Index. The influence of various factors upon treatment and long-term outcome was analysed. According to the PAR Index, orthodontic treatment reduced the malocclusions on average by 76.7 per cent, and at follow-up the reduction was 63.8 per cent. Follow-up stability was good for 76.3 per cent of the cases. Some cases (4.0 per cent) even improved, while moderate to severe post-treatment relapse occurred in 19.7 per cent of the cases. Orthodontic treatment changed Angle Class I, II and III malocclusions to near ideal occlusion (PAR scores 4.4–6.8). No long-term interaction between the groups was discovered. Sex and extraction/non-extraction treatments did not significantly affect the results. The initial PAR score accounted for 77.8 per cent of the variation in treatment PAR score change (T_1–T_2), and for 61.8 per cent of the variation of long-term PAR score change (T_1–T_3). Age at treatment start accounted significantly for the variability of treatment changes ($P < 0.001$). The PAR score at the end of treatment had some explanatory importance ($R^2 = 0.099$) for the long-term (T_1–T_3) result. However, PAR score changes in the follow-up period were difficult to predict.

Introduction

The Peer Assessment Rating (PAR) Index developed by Richmond (1990) and Richmond *et al.* (1992a,c) to measure treatment outcome takes into consideration occlusal changes, and has been found to be as reliable and valid as other occlusal indices (Richmond *et al.,* 1992b; Buchanan *et al.*, 1993). There are basically two methods of assessing improvement using the PAR Index: (1) reduction in the weighted PAR score and (2) percentage reduction in the weighted PAR score. This approach to evaluate orthodontic treatment outcome parallels the view of Berg (1991), who compared quantification of occlusion to general orthopaedics in medicine, where the degree of restitution of a handicap is frequently expressed as a percentage of the ideal. The PAR Index does not measure iatrogenic effects such as enamel lesions, marginal bone loss and apical root resorption as discussed by Kvam (1985) and Linge and Linge (1991).

Richmond and Andrews (1993) found that specialist orthodontic treatment on average reduced the malocclusion (PAR Index) by 78 per cent. Richmond *et al.* (1992c) proposed criteria for high-standard orthodontic treatment: the mean PAR reduction should be greater than 70 per cent, the number of cases allocated to the 'Worse–no different' category should be negligible, and the number allocated to 'Greatly improved' greater than 40 per cent.

A major objective of orthodontic treatment is to maintain long-term stability. Research and clinical data indicate that changes in orthodontic treatment results are to be expected (Riedel, 1988; Little, 1990). In relation to cost, duration and efforts invested in orthodontic therapy, a 5-year follow-up period is not very long. However, a high degree of stability after 20 years exceeds the usual expectations in other fields of medicine and dentistry (Berg, 1991). The post-treatment changes in a great number of cases may result in only minor negative changes. Most persons having minor malocclusion are not

in need of orthodontic treatment and are not concerned about their dentition (Helm, 1990; Espeland *et al.*, 1992; Birkeland *et al.*, 1995). Research findings indicate that 35–40 per cent of Caucasians fall into this category (Helm, 1971; McLain and Proffit, 1985; Brook and Shaw, 1989; Espeland *et al.*, 1992). No reports have so far used the PAR Index approach in a long-term study of treatment results. Biological variations may make it unreasonable to apply the same score requirements 5 years post-retention as at end of treatment. However, the PAR Index is capable of objectively measuring change, and thus brings us closer to what criteria should be applied to assess long-term results.

The aims of this study were to:

1. Assess the treatment results in a postgraduate clinic.
2. Assess the occlusion at a 5 year follow-up control, in relation to the original malocclusions, and the changes occurring in the follow-up period.
3. Determine whether treatment and post-treatment changes of the PAR Index were related to the original Angle classification.
4. Determine whether treatment and post-treatment changes could be related to extraction/non-extraction therapy.

Subjects and methods

Subjects

The subjects comprised patients having finished orthodontic treatment at the postgraduate clinic, Department of Orthodontics and Facial Orthopedics, University of Bergen, from 1976 to 1988, who had complete records and had attended controls 5 years after the end of retention. At the start of the investigation, 699 patients who had been out of retention for 5 years were registered in the clinic's files. Of these, 250 had attended the 5-year control. Twenty-six were discarded due to lack of satisfactory records, reducing the number to 224 cases, including 120 females (53.6 per cent) and 104 males (46.4 per cent).

At the start of treatment, 99 cases were Angle Class I, 93 Angle Class II division 1, 16 Angle Class II division 2, and 16 were Angle Class III malocclusions. Ninety-seven patients had a history of introductory treatment with removable appliances in the department's undergraduate clinic. In the postgraduate clinic, all patients were treated with fixed appliances (Table 1a). Age at treatment start, treatment and retention duration are described in Table 1a and b. Records including lateral cephalograms, orthopantomograms, intraoral X-radiographs, colour slides, photographs, and treatment plan, progression and evaluation, were available for all patients.

Methods

The two components of the Index of Orthodontic Treatment Need (IOTN), the Aesthetic Component (AC) and the Dental Health Component (DHC) (Brook and Shaw, 1989), and the PAR Index (Richmond, 1990; Richmond *et al.*, 1992a,b,c) were applied to three sets of dental casts for each patient: at the start of treatment (T_1), at the end of active treatment (T_2) and 5 years out of retention (T_3).

The PAR Index includes the scores of seven individual traits: alignment of upper and lower anterior segment, right and left buccal occlusion, overjet, overbite and centreline. The individual traits were weighted according to Richmond *et al.* (1992b). The result is the weighted PAR Index, which is used in this presentation. The percentage PAR score reduction indicates the success of treatment. The degree of improvement is organized into three categories: 'Worse–no different', 'Improved' and 'Greatly improved'. There must be at least a 30 per cent PAR score reduction and less than 22 PAR points reduction as a result of treatment for a case to be assigned 'Improved', and a change of at least 22 points for it to be assigned as 'Greatly improved' (Richmond, 1990; Richmond *et al.*, 1992c). These criteria used on PAR score changes T_1–T_2 and T_1–T_3 make it possible to compare the treatment outcome and the long-term results.

The model recordings were performed by two examiners, both calibrated at the Occlusal Index Calibration Course, held by Richmond in 1993. After an interval of 2 weeks, 30 model sets were

Table 1a Age at start of introductory and comprehensive treatment, treatment and retention duration and number of visits (range in parentheses).

	Introductory treatment in student clinic (N = 97)		Comprehensive treatment in postgraduate clinic (age <18 years, N = 202)		Comprehensive treatment in postgraduate clinic (age ≥18 years, N = 22)	
	Mean	Min–max	Mean	Min–max	Mean	Min–max
Age at treatment start						
Years	8.8	(6.9–13.3)	12.5	(9.1–17.3)	28.6	(18.3–48.2)
Duration of treatment						
Number of months	17.7	(2–62)	25.0	(4–62)	24.2	(9–55)
Number of visits	12	(3–37)	25	(7–52)	23	(4–49)
Duration of retention						
Number of months			21.3	(0–72)	15.0	(0–35)
Number of visits			9	(0–36)	8	(0–31)

Table 1b Distribution of patients according to type of comprehensive treatment and retention appliances (percentage in parentheses).

	Age <18 years	Age ≥18 years
Treatment appliances		
Fixed appliances both jaws	184 (91.1)	16 (72.7)
Fixed appliance one jaw	18 (8.9)	6 (27.3)
Retention appliances		
Removable or none	52 (25.7)	2 (9.1)
Fixed retainer and Hawley plate	150 (74.3)	20 (90.9)

randomly selected, and rated by both examiners as a validation exercise.

Statistical procedures

Interexaminer agreement on the DHC and AC was analysed by the kappa statistic (Landis and Koch, 1977). For the PAR Index, interexaminer reliability was evaluated by the intraclass correlation coefficient (Fleiss, 1986) and summary statistics of measurement error (Bland and Altman, 1986). The Kruskal–Wallis and Mann–Whitney tests were applied to test distribution differences in Angle Class groups on improvement categories. A repeated ANOVA was used to test the relation of the PAR Index pre-treatment, post-treatment and at follow-up, for improvement categories and in the Angle Class groups. One-way ANOVA was applied to test for mean differences between groups at each time level, with Scheffe's multiple range test for pairwise comparison between groups. The variables for treatment outcome and long-term results were analysed with a stepwise multiple regression procedure with possible explanatories:

1. Pre-treatment PAR score (PAR pre).
2. Pre-treatment AC (grade 1–10).
3. Pre-treatment DHC (grade 1–5).
4. Age at treatment start (years).
5. Treatment duration (months).
6. Sex (0 = male, 1 = female).
7. Extraction of teeth (0 = non-extraction, 1 = extraction or hypodontia).
8. Introductory treatment (0 = no introductory treatment, 1 = introductory treatment).
9. Treatment appliances (0 = fixed appliances one jaw, 1 = fixed appliances both jaws).
10. Angle Class (the four groups transformed to three indicator variables).

For the long-term outcome and follow-up changes, additional possible explanatories are as follows:

11. Retention appliance (0 = removable or none, 1 = fixed 3–3 retainer and Hawley plate).

12. Retention duration (months).
13. Post-treatment PAR score (PAR post).
14. Treatment change in PAR score.

The statistical analyses were performed by SPSS for Windows (Norusis, 1992).

Results

Reliability analysis of interexaminer agreement resulted in kappa values of 0.69 for AC and 0.83 for DHC. The values were interpreted as substantial to almost perfect agreement beyond chance. Analysis of reliability on PAR scores between the two examiners resulted in an intraclass correlation coefficient of 0.96, and there was no bias between the two examiners.

Pre-treatment, 56 cases (25 per cent) had a PAR score less than 22 and 168 cases (75 per cent) a PAR score greater than or equal to 22. Table 2 shows the treatment result (T_2) and long-term outcome (T_3). Orthodontic treatment reduced the PAR score 76.7 per cent. Post-treatment, seven cases (3.1 per cent) were categorized as 'Worse–no different', 100 (44.7 per cent) as 'Improved' and 117 (52.2 per cent) as 'Greatly improved'. At follow-up, the average PAR score reduction was 63.8 per cent for the total group, 62.7 per cent for the 'Improved' and 79.8 per cent for the 'Greatly improved' categories. Changes in the follow-up period brought about some shift of improvement categories compared with the situation at the end of treatment (Tables 2 and 3). The 'Worse–no different' category increased from seven to 25 cases (11.1 per cent) because of a relapse in 15 cases classified as 'Improved' and in four cases classified as 'Greatly improved' at T_2, while one case improved (Table 3). Nine cases (4.0 per cent) improved one category after treatment, 40 cases (17.9 per cent) relapsed one category, and four cases (1.8 per cent) relapsed two categories after

Table 2 PAR score changes and improvement categories post-treatment (T_2) and at follow-up (T_3) (category criteria as used by Richmond *et al.*, 1992c).

	PAR score change (T_1–T_2)					PAR score change (T_1–T_3)				
	Mean	SD	Min	Max	*n*	Mean	SD	Min	Max	*n*
Total	22.7 (76.7)	10.2	–3.0	51.0	224	19.1 (63.8)	10.4	–11.0	43.0	224
Worse–no different	1.1 (3.7)	4.0	–3.0	7.0	7	1.6 (4.6)	5.4	–11.0	8.0	25
Improved	15.1 (70.1)	4.8	3.0	21.0	100	14.3 (63.2)	4.6	2.0	21.0	103
Greatly improved	30.4 (86.4)	6.4	22.0	51.0	117	28.7 (79.8)	5.3	22.0	43.0	96

Values in parentheses are percentages.

Table 3 Cross-table of improvement categories defined at post-treatment and follow-up.

Distribution of improvement categories defined by changes in PAR score from pre-treatment (T_1) to post-treatment (T_2)	Distribution of improvement categories defined by changes in PAR score from pre-treatment (T_1) to follow-up (T_3)			
	Worse–no different T_3	Improved T_3	Greatly improved T_3	Row total
Worse–no different T_2	6	1	0	7 (3.1)
Improved T_2	15	77	8	100 (44.6)
Greatly improved T_2	4	25	88	117 (52.2)
Column total	25 (11.1)	103 (46.0)	96 (42.9)	224 (100.0)

The row totals represent the results at end of treatment and the column totals represent the results at 5-year follow-up control. Values in parentheses are percentages.

Table 4 Relationship of pre-treatment (T_1), post-treatment (T_2) and follow-up (T_3) PAR scores for the total group and Angle classifications with extraction and non-extraction subgroups. Values in parentheses are percentages.

	n	Mean PAR at T_1	Mean PAR at T_2	Mean PAR at T_3	Mean PAR change T_1–T_2	Mean PAR change T_1–T_3	Mean PAR change T_3–T_2
Total group	224	28.7	6.0	9.6	22.7 (76.7)	19.1 (63.8)	3.5 (12.9)
Non-extraction	71	26.8	5.6	8.7	21.2 (76.5)	18.1 (63.8)	3.1 (12.7)
Extraction/agenesis	153	29.6*	6.2	10.0	23.3 (76.8)	19.6 (63.8)	3.8 (12.9)
Angle Class I	99	26.3	6.0	9.0	20.3 (74.3)	17.3 (62.6)	3.0 (11.7)
Non-extraction	30	24.3	6.2	7.8	18.1 (74.5)	16.5 (65.4)	1.6 (9.1)
Extraction/hypodontia	69	27.2	5.9	9.6	21.3 (74.2)	17.6 (61.3)	3.6 (12.9)
Angle Class II, division 1	93	30.7**	6.2	10.1	24.5 (78.4)	20.6 (64.6)	3.8 (13.8)
Non-extraction	30	28.2	5.5	9.0	22.7 (76.4)	19.2 (63.0)	3.5 (13.4)
Extraction/hypodontia	63	31.9	6.6	10.6	25.3 (79.4)	21.3 (65.4)	4.0 (14.0)
Angle Class II, division 2	16	26.1	4.4	7.2	21.7 (80.8)	18.9 (69.8)	2.8 (11.0)
Non-extraction	7	25.6	3.3	6.7	22.3 (86.2)	18.9 (73.7)	3.4 (12.5)
Extraction/hypodontia	9	26.6	5.2	7.5	21.4 (76.6)	19.0 (66.8)	2.3 (9.8)
Angle Class III	16	34.7***	6.8	12.5	27.9 (77.3)	22.2 (61.1)	5.7 (16.2)
Non-extraction	4	37.5	6.3	17.0	31.2 (76.2)	20.5 (41.9)	10.7 (34.3)
Extraction/hypodontia	12	33.8	6.9	11.0	26.9 (77.7)	22.8 (67.6)	4.1 (10.1)

*$P < 0.05$ extraction versus non-extraction group.
**$P < 0.05$ Angle Class II, division 1 versus Angle Class I.
***$P < 0.05$ Angle Class III versus Angle Class I.

the end of treatment, while 171 (76.3 per cent) were stable.

Treatment improved all Angle Classes to near ideal occlusion with mean PAR scores of 4.4–6.8. (Table 4). Repeated ANOVA measures showed significant all-over change in the PAR scores ($P < 0.001$). There were differences between the Angle Class groups ($P < 0.001$) on PAR scores over time (T_1, T_2, T_3), but no interaction effect ($P > 0.05$) (Table 4, Figure 1). One-way ANOVA displayed group differences only at pre-treatment ($P < 0.001$); Angle Class II division 1 and Class III had more severe malocclusions than Angle Class I ($P < 0.05$). Angle Class II division 1 displayed greater improvement than Angle Class I at the end of treatment ($P < 0.05$), and the tendency was the same ($P < 0.1$) at the follow-up control (Table 5). The Angle Class groups behaved similarly according to the amount of PAR score change T_3–T_2 (Figure 1). Bivariate correlations between changes in the seven components of the PAR

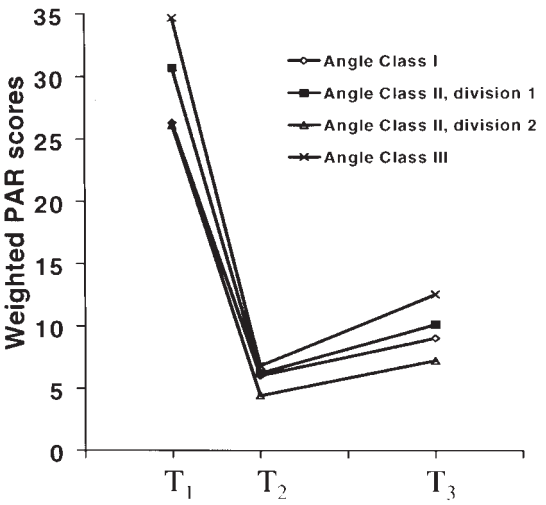

Figure 1 Graphic illustration of pre-treatment Angle Class groups showing how orthodontic treatment changed the weighted mean PAR scores, and the changes taking place in the period from the end of treatment to the 5-year follow-up control. Angle Class I and Angle Class II, division 2 overlap at start of treatment.

Table 5 Distribution of improvement categories according to PAR Index at post-treatment (T_2) and follow-up (T_3) in the Angle Class subgroups. Values in parentheses are percentages.

Subgroups	Post-treatment improvement categories according to PAR Index, changes from T_1 to T_2			Follow-up improvement categories according to PAR Index, changes from T_1 to T_3		
	Worse–no different	Improved	Greatly improved	Worse–no different	Improved	Greatly improved
Angle Class I	4 (4.0)	53 (53.5)	42 (42.4)	15 (15.2)	51 (51.5)	33 (33.3)
Angle Class II, division 1	3 (3.2)	31 (33.3)	59 (63.4)	8 (8.6)	37 (39.8)	48 (51.6)
Angle Class II, division 2	0	10 (62.5)	6 (37.5)	0	10 (62.5)	6 (37.5)
Angle Class III	0	6 (37.5)	10 (62.5)	2 (12.5)	5 (31.2)	9 (56.3)
	Kruskal–Wallis test: $P < 0.05$			Kruskal–Wallis test: $P = 0.05$		

Table 6 Stepwise multiple regession analysis.

Step	R	R^2	R^2 change	Sign. F change
*Equation 1. Pre-treatment patient characteristics (PAR score and age) and their influence on treatment outcome (T_1–T_2)**				
1. Pre-treatment PAR score	0.88	0.778	0.778	<0.001
2. Age	0.90	0.806	0.028	<0.001
*Equation 2. Patient characteristics and their influence on the long-term result (T_1–T_3)***				
1. Pre-treatment PAR score	0.78	0.618	0.618	< 0.001
2. PAR score at end of treatment	0.85	0.717	0.099	< 0.001

*PAR score reduction T_1–T_2 = –1.46 + 0.96 PAR pre – 0.27 Age; $F = 458.1$; $P < 0.001$.
**PAR score reduction T_1–T_3 = –2.50+ 0.90 PAR pre – 0.68 PAR post; $F = 279.2$; $P < 0.001$.

Index and change of PAR score indicate that increase in overjet contributed most to follow-up changes for all the Angle Class groups.

PAR score change was used as a dependent variable in a stepwise regression procedure with all explanatories described in Methods as independent variables. The results of the stepwise regression procedure are shown in Table 6. Pre-treatment PAR score accounted for 77.8 per cent of the variability in PAR score change in the treatment period ($R^2 = 0.778$). Pre-treatment AC and DHC, extraction/non-extraction and treatment duration were highly correlated to pre-treatment PAR score, and were not selected as additional predictors in the stepwise regression procedure. Age at treatment start added 2.8 per cent explanation to the variability of the treatment outcome. For the long-term results, the stepwise regression procedure entered pre-treatment PAR score as the most important explanatory ($R^2 = 0.618$), while PAR score at T_2 explained an additional 10 per cent ($R^2 = 0.099$). Equations for the prediction of treatment and long-term reduction in PAR score are given in Table 6. PAR score change in the follow-up period, T_3–T_2, was correlated to PAR change in the treatment period, T_1–T_2 ($r = 0.25$). However, changes in the treatment period explained only 6.6 per cent of the variability in follow-up changes. Neither pre-treatment PAR score ($R^2 = 0.061$) nor post-treatment PAR score ($R^2 = 0.029$) were important explanatories for changes in the follow-up period.

Discussion

This study includes 224 cases with complete records up to 5 years out of retention. They represent only 36 per cent of the treated cases that were called for a 5-year follow-up control,

and an important question is then: are the treatment results for this group representative for all cases treated in the postgraduate clinic? In order to answer this question, IOTN and PAR Index were applied to 30 treated cases, randomly selected among those not attending the follow-up control. The treatment result of this group was a 76.9 per cent PAR score reduction. No significant difference was found between the study group and this control group for mean pre-treatment PAR score and mean PAR reduction during treatment. It seems likely, therefore, that the material is representative for the treatment results in general.

The treatment reduced the malocclusions by about 77 per cent and resulted in a distribution to improvement categories which indicates a high standard of treatment (Richmond *et al.*, 1992c). The results correspond well with other reports on orthodontic treatment with fixed appliances (Fox, 1993; Richmond, 1993; Richmond and Andrews, 1993). According to the PAR Index, 217 (96.9 per cent) patients demonstrated beneficial occlusal changes from the treatment. Cases displaying no benefit from treatment were mild malocclusions, adult cases with a history of multiple early extractions, malocclusions with impacted teeth in a lateral segment, and hypodontia of premolars. These two last traits are weighted zero in the PAR Index, and consequently no benefit of treatment is recorded. Thus, the PAR Index is not always able to evaluate the outcome of treatment.

The long-term result of 64 per cent PAR score reduction implies a loss of about 13 per cent of what was gained by treatment. However, most cases (88.9 per cent) retained the benefit of treatment. No comparable studies for long-term treatment success measured by PAR Index are available. Unchanged results in the follow-up period would probably be too ambitious. Many studies report post-retention changes in tooth positions, overjet and overbite (Little *et al.*, 1981, 1988; Sadowsky and Sakols 1982; Riedel, 1988; Little, 1990). Long-term changes are also found in untreated normals, i.e. increase of overjet and anterior irregularity (Sinclair and Little, 1983). According to Richmond *et al.* (1992c), a treatment reduction of the original malocclusion of 70 per cent or more indicates a good standard of treatment. Owing to expected changes, our findings of 64 per cent malocclusion reduction and 43 per cent of the cases 'Greatly improved' is probably within the limits of good long-term results.

The treatment success was greatest for Angle Class II division 2 with 80.8 per cent PAR score reduction, closely followed by Angle Class II division 1 (78.4 per cent). The long-term success was also best for Angle Class II division 2, and Angle Class II division 1 (69.8–64.6 per cent), while the Angle Class III group displayed the greatest relapse (16.2 per cent of treatment gain). The reason may be different growth changes in Class III patients with an accentuation of Class III growth pattern in the last part of the growth period (Brodie, 1953; Bjørk and Skieller, 1983). Overall statistical analyses did not display a significant effect of Angle classification for the long-term result measured by the PAR score change, except for the distribution to improvement categories. The fact that Angle Class II division 1 had a better result than Angle Class I can be explained by different pre-treatment PAR scores. The good treatment and long-term results for Angle Class II division 1 malocclusion correspond well with the results of Fidler *et al.* (1995). Extractions did not significantly influence treatment success, which indicates that when fixed appliances are used, there is a prospect of achieving good results both with and without extractions, as also reported earlier by Uhde *et al.* (1983) and Fidler *et al.* (1995). Lobb *et al.* (1994) reported that extractions during treatment were associated with more frequent treatment failures, but in their material the treatment was provided by removable appliances in most cases.

The pre-treatment PAR score was a good predictor of both treatment result and long-term outcome. This study's regression equations, compared with those of Kerr *et al.* (1994), confirm that patients with marked malocclusions can be treated to more ideal standards with fixed than with removable appliances. There was no sex difference in the treatment outcome in our study. This is in contrast to the finding by Kerr *et al.* (1994), who studied removable appliances,

and found better results for girls. The reason may be that treatment with fixed and removable appliances require different levels of co-operation. Age was the second best explanatory for the treatment results. The age at treatment start ranged from 6.9 to 48.2 years. The regression equation shows that less treatment PAR change should be expected in higher age groups. The explanation may be that in some adults the treatment aims were limited, i.e. pre-prosthetic corrections. However, long-term stability was independent of age, as also observed by Harris *et al.* (1994). The stepwise regression analysis confirms that post-treatment ideal occlusion (low PAR post) is important for a good long-term result.

Only a small change in PAR score is sufficient to change a case from one category to another. Nineteen cases that changed from the two best categories to 'Worse–no different' were examined for PAR component change. Increase in overjet (r = 0.88) and overbite (r = 0.66) were most frequently the reason for the PAR score increase. The great influence of overjet increase is related to its high weighting (6) in the PAR Index. DeGuzman *et al.* (1995) proposed less weighting (4.5) on overjet when used to assess the severity of malocclusion, which will reduce its influence. Additionally, the low limit for scoring normal overjet (0–3.0 mm) will also affect the influence of overjet. According to the PAR Index, an overjet increase from 3.1 to 3.5 causes a change of 6 weighted PAR points. However, this is within the normal range in other reports (Sadowsky and Sakols, 1982; Brook and Shaw, 1989) that have 3.5 mm as a lower limit for excessive overjet.

For the total group, small post-retention changes were found for all seven PAR components. Changes of anterior crowding were found to be inferior to changes of the weighted overjet. Comparison with other reports (Sadowsky and Sakols, 1982; Udhe *et al.*, 1983; Little *et al.*, 1988; Zaher *et al.*, 1994) are difficult, since different criteria are used. The PAR Index is sensitive for small changes from ideal intercuspidation of all teeth from canines to third molars, and consequently even small changes will affect the PAR Index, and few cases will be assigned a score of zero for buccal occlusion. To interpret the long-term result, it is important to be aware that a case can be assigned a PAR scores of 6 and still have no need for treatment according to IOTN. The PAR score can be relatively high (7–20) if there are minor deviations for all seven components, and still a case may be assigned to little need for treatment. However, another case with a PAR score of 18 may be in need of treatment if it is due to scoring of a single component as overjet (7.1–9 mm). In this study, the follow-up changes of PAR scores resulted in only minor deviations from normal occlusion for the majority of cases. Follow-up PAR score changes were not significantly affected by pre-treatment Angle classification. The PAR components are compound variables, i.e. overjet can be both positive overjet and anterior crossbite, buccal occlusion can be scored by crossbite, lateral open bite and cuspal interdigitation, and this is the strength of the PAR Index when used for overall comparisons between groups. Bivariate correlation analyses between the change in PAR score and the change in PAR components indicate different effects in Angle Classes. In order to analyse details of post-retention influence of occlusal traits, a different approach is necessary. However, the PAR Index has potential for further development.

Only 6–9 per cent PAR score change during the follow-up period could be explained either by pre- or post-treatment PAR score, or change in PAR score during treatment. About 90 per cent of the changes in the follow-up period could not be predicted. Possible explanations for the unpredictable changes are related to growth (Bjørk and Skieller, 1983; Glenn *et al.*, 1987; Richardson, 1994) and the normal maturation of the occlusion that takes place after the end of orthodontic treatment (Sinclair and Little, 1983).

Clinically, it is important to be aware of pre-treatment PAR score as a useful predictor also for long-term results. Further studies are needed to verify whether the post-retention changes shown in this study are within acceptable ranges, and to search for factors that can explain why some cases show unfavourable post-retention changes. The PAR Index is not the

optimal tool for evaluation of treatment benefits. Being an occlusal index, it does not consider all factors that are important for the total quality of treatment, i.e. treatment duration, caries, white spots, root resorptions, facial aesthetics and the patient's own assessment of treatment. However, it is helpful to compare treatment standards and long-term results for different groups and treatment systems, and therefore of great clinical importance.

Address for correspondence

Dr. Kari Birkeland
Department of Orthodontics and Facial Orthopedics
University of Bergen
Årstadveien 17
N-5009 Bergen
Norway

Acknowledgement

The Faculty of Dentistry, University of Bergen, is acknowledged for the financial support of this study.

References

Berg R 1991 Evaluation of orthodontic results—a discussion of some methodological aspects. The Angle Orthodontist 61: 261–266

Birkeland K, Bøe O E, Wisth P J 1996 Orthodontic concern among 11-year-old children and their parents compared with orthodontic treatment need assessed by index of orthodontic treatment need. American Journal of Orthodontics and Dentofacial Orthopedics 110: 197–205

Bjørk A, Skieller V 1983 Normal and abnormal growth of the mandible. A synthesis of longitudinal cephalometric implant studies over a period of 25 years. European Journal of Orthodontics 5: 1–46

Bland J M, Altman D G 1986 Statistical methods for assessing agreement between two methods of clinical measurement. Lancet i: 307–310

Brodie A G 1953 Late growth changes in human face. The Angle Orthodontist 23: 146–157

Brook P H, Shaw W C 1989 The development of an index of orthodontic treatment priority. European Journal of Orthodontics 11: 309–320

Buchanan I B, Shaw W C, Richmond S, O'Brien K D, Andrews M 1993 A comparison of the reliability and validity of the PAR Index and Summers' Occlusal Index. European Journal of Orthodontics 15: 27–31

DeGuzman L, Bahiraei D, Vig K W L, Vig P S, Weyant R J, O'Brien K 1995 The validity of the Peer Assessment Rating Index for malocclusion severity and treatment difficulty. American Journal of Orthodontics and Dentofacial Orthopedics 107: 172–176

Espeland L V, Ivarsson K, Stenvik A 1992 A new Norwegian index of orthodontic treatment need related to orthodontic concern among 11-year-olds and their parents. Community Dentistry and Oral Epidemiology 20: 274–279

Fidler B C, Årtun J, Joondeph D R, Little R M 1995 Long-term stability of Angle Class II, division 1 malocclusions with successful occlusal results at end of active treatment. American Journal of Orthodontics and Dentofacial Orthopedics 107: 276–285

Fleiss J L 1986 Design and analysis of clinical experiment. Wiley, New York

Fox N A 1993 The first 100 cases: a personal audit of orthodontic treatment assessed by the PAR (Peer Assessment Rating) Index. British Dental Journal 174: 290–297

Glenn G, Sinclair P M, Alexander R G 1987 Nonextraction orthodontic therapy: Posttreatment dental and skeletal stability. American Journal of Orthodontics and Dentofacial Orthopedics 92: 321–328

Harris E F, Vaden J L, Dunn K L, Behrents R G 1994 Effect of patient's age on post-orthodontic stability in Class II, division 1 malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics 105: 25–34

Helm S 1971 Prevalence of malocclusion in relation to development of the dentition. PhD Thesis. Acta Odontologica Scandinavica, supplement 28

Helm S 1990 Reappraisal of the criteria for orthodontic treatment. PhD Thesis, University of Oslo, Norway

Kerr W J S, Buchanan I B, McNair F I , McColl J H 1994 Factors influencing the outcome and duration of removable appliances. European Journal of Orthodontics 16: 181–186

Kvam E 1985 Adverse effect of orthodontic treatment. In: Thilander B, Rønning O (eds.) Introduction to orthodontics. Tandläkareförlaget, Stockholm, pp. 225–233

Landis J R, Koch G G 1977 The measurement of observer agreement for categorical data. Biometrics 33: 159–174

Linge L, Linge B O 1991 Patient characteristics and treatment variables associated with root resorption during orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 99: 35–43

Little R M 1990 Stability and relapse of dental arch alignment. British Journal of Orthodontics 17: 235–241

Little R, Wallen T, Riedel R 1981 Stability and relapse of mandibular anterior alignment—first premolar extraction cases treated by traditional edgewise orthodontics. American Journal of Orthodontics 80: 349–365

Little R M, Riedel R A, Årtun J 1988 An evaluation of changes in mandibular anterior alignment from 10 to 20 years postretention. American Journal of Orthodontics and Dentofacial Orthopedics 93: 423–428

Lobb W K, Ismail A I, Andrews C L, Spracklin T E 1994 Evaluation of orthodontic treatment using the dental aesthetic index. American Journal of Orthodontics and Dentofacial Orthopedics 106: 70–75

McLain J B, Proffit W R 1985 Oral health status in the United

States: Prevalence of malocclusion. Journal of Dental Education 49: 386–396

Norusis M 1992 SPSS for Windows. Release 5. Copyright by SPSS Inc., Chicago, Illinois

Richardson, M E 1994 Late lower arch crowding: The role of differential horizontal growth. British Journal of Orthodontics 21: 379–385

Richmond S 1990 A critical evaluation of orthodontic treatment in the General Dental Services of England and Wales. PhD Thesis, University of Manchester

Richmond S 1993 Personal audit in orthodontics. British Journal of Orthodontics 20: 135–145

Richmond S, Andrews M 1993 Orthodontic treatment standards in Norway. European Journal of Orthodontics 15: 7–15

Richmond S, O'Brien K, Buchanan I, Burden D 1992a An introduction to occlusal indices. Victoria University of Manchester

Richmond S *et al*. 1992b The development of the PAR Index (Peer Assessment Rating): reliability and validity. European Journal of Orthodontics 14: 125–139

Richmond S, Shaw W C, Roberts C T, Andrews M 1992c The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. European Journal of Orthodontics 14: 180–187

Riedel R 1988 A post-retention assessment of relapse, recidivism, adjustment, change and stability. In: Moorrees C F A, van der Linden F P G M (eds.) Orthodontics: evaluation and future. Department of Orthodontics, University of Nymegen, The Netherlands, pp. 281–306

Sadowsky C, Sakols E I 1982 Long-term assessment of orthodontic relapse. American Journal of Orthodontics 82: 456–463

Sinclair P M, Little R M 1983 Maturation of untreated normal occlusions. American Journal of Orthodontics 83: 114–123

Uhde M D, Sadowsky C, BeGole E A 1983 Long-term stability of dental relationships after orthodontic treatment. The Angle Orthodontist 53: 240–252

Zaher A R, Bishara S E, Jakobsen J R 1994 Post-treatment changes in different facial types. The Angle Orthodontist 64: 425–436