Occlusal outcome of orthodontic treatment

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Orthodontists and health care providers show increased interest in the efficiency of orthodontic treatment for correction of malocclusion. However, it is sometimes difficult to objectively assess treatment outcome. Over the years, several indices have been developed to assess treatment success.[1-4] One of the earliest studies was performed by Myrberg and Thilander.[5] They examined 1486 treated cases and graded the treatment results according to a five-point scale: good, acceptable, less good, poor, and no effect. Good results were obtained in 54% of the cases. The occlusal index,[6] which was initially designed for other tasks, has also been used to evaluate the success of treatment.[7-9] Other methods include the six keys to optimal occlusion[10] and the peer assessment rating index (PAR index).[4,11] The aim of many of these indices is to assess malocclusion in a large sample. Scores are applied to the dental and the occlusal features of a certain malocclusion and the sum of these scores ranks the malocclusion.

In recent years several studies have been conducted in the United Kingdom in which the outcome of orthodontic treatment has been assessed using the PAR index. In an investigation within the General Dental Service in England and Wales, orthodontic treatment standards appeared to be poor.[12] A comparable study was done at 17 hospital-based orthodontic departments. The mean percentage change in the PAR score of all the departments was 67.6%, and 8%

Abstract

The aim of this study was to evaluate the overall quality of orthodontic treatment in a university clinic. Dental casts of 1870 patients (799 males and 1071 females) were evaluated at the pretreatment and posttreatment stages using the PAR index. The mean age was 13 ± 4.1 years at the pretreatment stage and 16 ± 3.9 years at the posttreatment stage. At both stages, mean and standard deviations of the (weighted) PAR scores were calculated, along with the percentage reductions in the weighted PAR scores. The percentage of perfect scores (score = 0) of the different components of the PAR index was calculated. The analysis of variance and *t*-test were used to compare quality of treatment for the variables of treatment period and gender, respectively. The mean weighted PAR scores were 27.6±10 and 7.7 ± 6.1 for the pretreatment and posttreatment models, respectively. The mean percentage improvement was 68.9%. The mean treatment duration was 3.0 ± 1.4 years. Great improvement was noted in 42.6% of the sample, while 49.1% of the sample showed moderate improvement, and 8.3% either did not improve or became worse. The improvement of the PAR score at the posttreatment stage could, to some extent, be explained by the treatment period: The more recent the period the better the quality.

Key Words

Quality • Treatment outcome • Dental casts • PAR index

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of the patients were allocated to the "worse-or-no-different" group.[13] An earlier pilot study also concluded that beneficial outcomes were found more often among patients treated at the Hospital Orthodontic Service than among those treated by the General Dental Service. The majority of the cases in that study showed substantial improvement after treatment. Only 4 patients out of 100 were allocated to the worse-or-no-different group.[9] O'Brien et al.[13] showed that the treatment outcome was influenced by the grade of the operator, the choice of treatment methods, and by departmental attitudes and aspirations. A correlation was also found between the PAR index and the index of orthodontic treatment need (IOTN), with the risk of getting an "unimproved-or-made-worse" treatment especially high for patients with borderline needs.[9] In a study performed in Norway, where nearly all orthodontic treatment was done by specialists, the standard of orthodontic treatment outcome was better than in the United Kingdom. The mean percentage reduction in weighted PAR score was 78%, and only 4% of cases were categorized as worse or no different.[14]

Recently, the PAR index was introduced to the United States, and several studies have been done. Feghali et al.[15] assessed a sample of 100 consecutively debonded orthodontic cases at Case Western Reserve University (CWRU) using the PAR index. The median pretreatment age was 13 years and the median treatment time was 32.7 months. The average pre- and posttreatment PAR scores were 34 ± 10 and 11 ± 5.6, respectively. The results demonstrated that 55% of the patients were "greatly improved," 41% "improved," and only 4% were defined as "no improvement." Another study at the same dental school compared cases debonded in 1993 and 1994 with those debonded between 1980 and 1985 and showed that the quality of orthodontic care delivered at CWRU remained stable.[16,17] Another comparative study was done between the graduate orthodontic clinics in Pittsburgh and Columbus, comparing the orthodontic treatment efficiency before and after 1984. The duration of treatment and the mean monthly rate of relative improvement in the PAR scores were assessed. Treatment efficiency in both programs increased as measured by decreased treatment time after 1984, although the mean monthly rates of reduction in the relative PAR score did not change.[18]

The aim of the present study was to evaluate the overall quality of orthodontic treatment and treatment time over a long time span in a large sample from a university clinic.

Material and methods

The archives of the Department of Orthodontics and Oral Biology, University of Nijmegen (The Netherlands), contain records of 2368 patients. Only the cases that had both pretreatment and posttreatment dental casts were included in this study. Standard orthodontic study models of 1870 patients (799 males and 1071 females) were evaluated at the pretreatment and posttreatment stages. The mean ages were 13 ± 4.1 years at the pretreatment stage and 16 ± 3.9 years at the posttreatment stage. Patients were categorized according to the year in which they finished active orthodontic treatment. Six posttreatment periods were distinguished: 1965-1970 (n=51); 1971-1975 (n = 140); 1976-1980 (n = 238); 1981-1985 (n = 460); 1986-1990 (n= 559); and 1991-1995 (n = 422).

The PAR index[4] was used to score pretreatment and posttreatment dental casts of the same patient. The index has seven components: upper anterior segment, lower anterior segment, left buccal occlusion, right buccal occlusion, overjet, overbite, and centerline. The individual scores for the various components are weighted according to the British weighting factors and summed to the so-called weighted PAR score, to be called PAR in this paper. A PAR of zero indicates good alignment, and higher scores (rarely beyond 50) indicate high levels of irregularity. The change in the total PAR reflects the degree of improvement and the success of orthodontic treatment. A malocclusion is defined as "greatly improved" when the posttreatment PAR is at least 22 points lower than the pretreatment PAR. The malocclusion is defined as "improved" when the score is 30% lower, and cases showing a drop in the PAR of less than 30% are defined as "not improved."[11]

Three examiners participated in the study and they were standardized in the use of the PAR index. To determine the measurement error and to assess intra- and interobserver agreement, a random sample of study models of 18 patients was evaluated by the three observers. For each patient, two different dental casts (one from the pretreatment stage and the other from 5 years postretention) were measured twice. The time interval between the two measurements was at least 3 months.

The magnitude of intra- and interobserver duplicate error in the PAR was calculated. Systematic differences between observers were tested by the paired *t*-test. Inter- and intraobserver reliabil-

ity was expressed as the Pearson's correlation coefficients between duplicate measurements.

To assess possible selectivity in missing records, patients who did (n = 1870) or did not (n = 498) have posttreatment records were compared on pretreatment characteristics using the *t*-test. Mean and standard deviation of the PAR were calculated at the pretreatment stage and at the end of active treatment. The percentage reduction in the PAR was calculated to assess improvement. Cases that changed from a very low initial PAR to a higher one with deterioration < -100% cause a negative skewness in the relative improvement distribution. To overcome this problem, the PAR improvement was divided by the maximum PAR value. This affects only the negative improvements. The mean percentage improvement was not affected; it changed from 67.7% to 68.9%. Analysis of variance and *t*-test were applied to compare the quality of treatment (PAR) for treatment period and gender, respectively. Multiple regression analysis was performed to correct for possible confounders.

Results

No significant systematic differences were found between observers (paired *t*-test). Reproducibility of the PAR index was high and is presented in Table 1.

Comparison of the sample of this study with the sample that contains all cases (*t*-test), showed that both groups were comparable with respect to gender, mean initial age, mean initial PAR, and Angle classification.

Significant differences between males and females were found for the mean PAR at the pretreatment and posttreatment stages, with the scores being higher in males. The mean treatment duration was 3.0 ± 1.4 years and was longer in males than in females. The mean PAR for the whole sample was 27.6 ± 10.0 initially and dropped to 7.7 ± 6.1 at posttreatment. The mean percentage improvement was 68.9% (Table 2). Of the total sample, 42.6% were greatly improved, 49.1% were improved, and 8.3% were not improved or became worse. Males were categorized as greatly improved (44.3%) or not improved (9%) more often than females (Table 3).

There were significant differences in the quality of treatment over time (Table 4). The percentage change in the PAR varied from 65.0% (SD 28.8%) to 76.1% (SD 23.0%) between the different time periods. This change in PAR over time remained after correction for confounders (sex, Angle classification, initial age, initial PAR). There was an uncorrected decrease in posttreatment PAR of 0.75 per decade; after correction for confounders, 0.62 per decade remained, indicating that the quality of orthodontic treatment increased over time. Treatment time varied from 2.8 (SD 1.4) to 3.2 (SD 1.4) years, which was also significantly different.

Table 1
Intra- and interobserver error and reliability of the assessment of the PAR index

Type of agreement	Error (points) (n = 108)	Measurement/remeasurement correlation Pretreatment (n = 18)	Posttreatment (n = 18)
PAR-intra	0.85	0.98 - 0.99	0.98 - 0.99
PAR-inter	1.94	0.92 - 0.99	0.96 - 0.98

Table 5 shows the percentage of perfect scores (score = 0) of the different components of the PAR index. Only 4% of the cases had perfect lateral occlusion at the end of active treatment. On the other hand, more than 80% of the cases had a perfect centerline and alignment of the upper and lower front teeth.

Discussion

Interest in quality control of orthodontic treatment is increasing. The PAR index[4] was developed both as a self-evaluation instrument for the practitioner to measure his or her own performance and as a measuring tool to assess overall quality in larger samples. The evaluation of large samples, as in the present study, provides more insight into the level of final treatment outcome that can be obtained. This can contribute to the development of standards for quality control in orthodontics.

In the present study, the overall pretreatment PAR was 27.6 ± 10 and the posttreatment PAR was 7.7 ± 6.1, but there were significant differences between the treatment periods. Improvement at the posttreatment stage can be explained to some extent by the treatment period: More recent periods produced better quality. For an institution as well as for a private office, such an analysis can contribute to the discussion of orthodontic treatment over the years. As such, it is an important tool in the process of total quality management in that specific clinic.

The sample of the present study was comparable to that at Case Western Reserve University, where the mean PAR was 34 ± 10 at the pretreatment stage and 11 ± 5.6 at the posttreatment stage.[15] Comparing results between the two studies shows that finishing of treatment was better in our study, but the percentage of cases in the

Table 2
Comparison of the mean weighted PAR score at the pretreatment (PARpre) and posttreatment (PARpost) stages, the relative improvement in PAR score, and the treatment duration for the whole sample and for males and females separately

	N	PARpre Mean SD	PARpost Mean SD	% change Mean SD	Duration Mean SD
Total	1870	27.6 ± 10	7.7 ± 6.1	68.9 ± 26.1	3.0 ± 1.4
Males	799	28.4 ± 10.2	8.2 ± 6.5	68.2 ± 26.3	3.2 ± 1.5
Females	1071	27.0 ± 9.8	7.4 ± 5.7	69.4 ± 25.9	2.9 ± 1.3
p-value		0.002	0.006	0.019	<0.001

p-value = *t*-test

Table 3
Classification of improvement for the whole sample and for males and females separately. Number (and percentage) are given for each category

	Greatly improved	Improved	Not improved
Total sample	796 (42.6%)	922 (49.1%)	152 (8.3%)
Males	354 (44.3%)	373 (46.7%)	72 (9.0%)
Females	442 (41.3%)	549 (51.3%)	80 (7.5%)

Greatly improved = more than 22 points reduction
Improved = more than 30% improvement
Not improved = less than 30% improvement

worse-or-no-different group was higher, 8.3%. The low percentage (4%) of cases categorized as worse or no different (less than 30% improvement) in the study of Feghali et al.[15] can be explained by the fact that the pretreatment scores in Ohio were higher, while the sample size was much smaller (n = 100). The higher the PAR at the pretreatment stage, the higher the chance of achieving more than 30% reduction.[9,19] Our finding regarding the mean percentage change in the PAR (68.9 %) compares very well with the findings of O'Brien et al.[13] in their investigation of 17 hospital-based orthodontic departments (67.6%). This comparability in the mean percentage change may be due to the similarity in the operator's level of experience—a mixture of senior and junior staff—in both studies. A higher percentage change (78%) was found in a Norwegian pilot sample, n=220, but there the orthodontic treatment was performed by specialists only.[14]

In our study there were significant differences between males and females in the percentage change of the PAR and in treatment duration. However, the differences were very small and not clinically relevant. The mean treatment duration in our study (3.0 ± 1.4 years) was comparable to the treatment duration in the orthodontic clinic at Case Western Reserve University (2.8 ± 1.6 years) and at the University of Southern California (2.9 ± 1.2 years).[20] It is remarkable, however, that treatment time did not diminish, although orthodontic techniques, especially fixed appliance techniques, evolved during the years.

The individual scores for the different occlusal traits show that a high percentage of cases had a perfect centerline and perfect alignment of the front teeth after treatment. It seems much more difficult to achieve perfect lateral occlusion, overbite, and overjet. In only 4% of the patients was it possible to achieve perfect lateral occlusion at the posttreatment stage. This may be due to the fact that the score for lateral occlusion is very sensitive to deviations from the norm: A very minor deviation from full interdigitation is already scored as nonoptimal occlusion. Furthermore, the recording zone for buccal occlusion extends from the canine to the last molar, either first, second or third, even if the second and third molars were not involved in the treatment due to their late eruption. These factors definitely will affect the final PAR score and, with that, the categorization into the three grades (greatly improved, improved, or worse/no different), especially in cases with a low initial PAR score. To improve the validity of the PAR for this recording, exclusion of the second and third molars from the recording and inclusion of and allowance for a certain (predefined) degree of deviation from full interdigitation should be considered. For example, a score of 1 should be given to the sagittal buccal occlusion only when two or more teeth have 0 to one-quarter premolar width deviation from full interdigitation. A perfect vertical relationship was achieved in only 54% of the patients. This may give an indication of the difficulty in treating overbite and openbite, at least in our sample. The results for overjet were slightly better.

The British weighting factors for overjet, overbite, lateral occlusion, and centerline are 6, 2, 1, and 4, respectively,[4] while the American weighting factors are 5, 3, 2, and 3.[21] These differences in weighting may be due to the difference in the design of the two studies that determined the validity of the PAR index. In the British validation study 74 dentists participated, representing the various groups carrying out orthodontic treatment in England and Wales; of that group, 48 had orthodontic specialty qualifications and 26 did not. On the other hand, in the U.S. validation study only 11 dentists, all with orthodontic specialty qualifications, were involved. The PAR index should be validated according to the orthodontic standard of the country involved, taking into account all panels concerned with orthodontic treatment, i.e., orthodontists and general practitioners.

Conclusion

In this large sample from a university a percentage change in the PAR score of 68.9% could be reached, while it appeared that the quality of the orthodontic treatment improved over the years. Validation of the PAR index according to the Dutch orthodontic standard is recommended.

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Table 4
Comparison of the mean PAR at the pretreatment (PARpre) and posttreatment (PARpost) stages, relative improvement in the PAR, and the treatment duration for the whole sample according to treatment period

Years	N	PARpre Mean SD	PARpost Mean SD	% change Mean SD	Duration Mean SD
65-70	51	29.5 ±11.5	6.3 ± 6.5	76.1 ± 23.0	2.8 ± 1.4
71-75	140	28.6 ± 9.6	8.2 ± 6.9	68.4 ± 27.8	3.1 ± 1.6
76-80	238	29.1 ±10.3	9.3 ± 7.6	65.0 ± 28.8	2.8 ± 1.4
81-85	460	27.8 ±10.4	8.1 ± 5.6	67.4 ± 25.5	3.1 ± 1.5
86-90	559	27.0 ± 9.6	7.1 ± 5.5	70.5 ± 24.7	2.9 ± 1.4
91-95	422	26.7 ± 9.7	7.2 ± 5.7	70.0 ± 26.4	3.2 ± 1.4
p-value		0.018	0.000	0.019	0.002

p-value = one way ANOVA

Table 5
Percentage of perfect scores (score = 0) at the posttreatment stage of the different components of the PAR index in 1870 patients

Component	Percentage score = 0	SE
Maxillary front	83 %	0.9
Mandibular front	86 %	0.9
Right and left occlusion	4 %	0.4
Overjet/anterior crossbite	62 %	1.1
Overbite/openbite	54 %	1.2
Centerline	88 %	.09

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