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Panel perception of change in facial aesthetics following orthodontic treatment in adolescents

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SUMMARY The aim of the study was to evaluate the influence of the characteristics of panel members, the effects of gender and Angle Class of adolescent patients on their change in facial aesthetics following orthodontic treatment, and to assess the optimal panel size for epidemiological studies on changes in facial aesthetics after orthodontic treatment.

A panel of 74 adult laymen (35 males and 39 females) and a panel of 87 orthodontists (37 males and 50 females) evaluated sets of three post-treatment standardized photographs (one frontal, one three-quarter smiling, and one lateral) of 64 adolescent orthodontic patients in relation to the pre-treatment sets of the same patient on a five-point scale. The main effects of professional background, age, gender, and geographic region of the panel members on the aesthetic scores, as well as their first order interactions were evaluated by multilevel models.

Professional background, age, gender, and geographical region of panel members have an influence on the evaluation of the change of facial aesthetics following orthodontic treatment. The effect of gender and Angle Class of the patients on the scores was evaluated by two-way analysis of variance. There was no difference in the mean scores for boys and girls. Improvement of facial aesthetics by orthodontic treatment was significant for Class I, Class II division 1, and Class II division 2 patients, but not for Class III patients.

Based on the intraclass correlation coefficient, a panel of nine randomly selected orthodontists, a panel of 14 randomly selected laymen, or a mixed panel of 13 individuals is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a five-point scale.

Introduction

The major reason why people seek orthodontic treatment is improvement of facial aesthetics (Birkeland *et al.*, 1999; Kiyak, 2000). Parents of young orthodontic patients expect that orthodontic treatment will improve the dental, dento-facial, and facial aesthetics of their children (McComb *et al.*, 1996). Orthodontists also consider improvement of facial aesthetics as an important treatment goal, and therefore, it is an important issue in their decision-making process and their treatment plans (Bowman and Johnston, 2001; Ackerman, 2004). The opinion of the general public, the end-users of orthodontic services, may have the most value in determining the appropriateness of aesthetic results (Bowman and Johnston, 2001). However, the question arises as to whether the general public appreciate facial change brought about by orthodontic treatment (and growth) in the same way as orthodontists. Literature on the subject is rare and mostly deals with orthognathic surgery (Dunlevy *et al.*, 1987; Shelly *et al.*, 2000). The few investigations on panel evaluation of facial aesthetics after orthodontic treatment have focussed on different treatment modalities. In those studies, comparisons were made between extraction versus non-extraction (Bowman and Johnston, 2000), different types of functional appliances versus non-treatment (O'Neill *et al.*, 2000), and orthognathic surgery versus non-surgical intervention (Phillips *et al.*, 1992). Only Kerr and O'Donnell (1990) evaluated differences in facial aesthetics in orthodontic patients, before and after treatment, as judged by four panels: art students, parents of children undergoing orthodontic treatment, dental students, and orthodontists. However, a drawback of that study was that Class II division 2 patients were not included and that each panel consisted of only four persons, which might be too small to draw reliable conclusions. Another problem in panel evaluation of facial aesthetics is that differences in panel composition concerning age and gender may be confounders (Spyropoulos and Halazonetis, 2001).

No publications are available on regional differences of panel members, assessing the change in facial aesthetics by orthodontic treatment in adolescents. This subject, however, could be of interest for orthodontists moving to other regions. Orthodontists working all over the world, evaluating their own treatment outcomes, should know whether they agree with their patients and their parents. They can benefit from this knowledge in their patient discussion on treatment expectations.

Panel size is another issue to be investigated. Howells and Shaw (1985) found that for the evaluation of facial aesthetics, good reliability was established with a two-person panel, but that an increase in panel size would improve the reliability. However, the optimal size of such a panel has never been established.

Since there is so little known about these topics, the aims of the present study were as follows.

1. Evaluation of the influence of, and the possible interactions between, professional background, age, gender, and geographical region of panel members on their perception of change in facial aesthetics following orthodontic treatment.
2. Evaluation of possible effects of gender and Angle Class of adolescent patients on their change in facial aesthetics following orthodontic treatment.
3. To find indications for an optimal panel size for clinical and epidemiological investigations on the change in facial aesthetics following orthodontic treatment.

Materials and methods

Sets of three standardized colour photographs (one frontal, one three-quarter smiling, and one lateral) of Caucasian patients from the 1990–2000 files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands, were selected. The inclusion criteria were between 10 and 16 years of age during complete orthodontic treatment, treatment time duration up to 3.3 years, not wearing glasses, no dental or facial trauma, or any known congenital defects. This treatment duration was chosen, since the average treatment time at the Department of Orthodontics, Radboud University Nijmegen, is approximately 3.3 years. From this group, which comprised 764 subjects, 64 patients were randomly selected after stratification for gender and Angle Class. The stratification was performed in order to obtain a wide variation of dental/skeletal characteristics and an equal gender distribution. Angle Classifications were defined as follows—Angle Class I: neutro-occlusion and neutro-relationship of the jaws; Class II division 1: disto-occlusion and disto-relationship of the jaws, with proclined upper incisors; Class II division 2: disto-occlusion and disto-relationship of the jaws, with retroclined upper incisors; and Class III: mesio-occlusion and mesio-relationship of the jaws.

The stratification aimed for approximately eight boys and eight girls for each of the four Angle Classes. The distribution of gender and Angle Class is given in Table 1. Neither the severity of the malocclusion nor the chosen treatment modality was important for this study, since the aim was to determine only the change in facial aesthetics after orthodontic treatment.

For each individual, a set of digitized images was prepared, showing simultaneously a frontal, a three-quarter smiling, and a lateral view before treatment and also a set of such images after treatment. These sets of images were used as stimuli in a panel evaluation. For that purpose, a panel of 76 adult laymen with a relatively high socio-economic status from Belgium and the Netherlands and a panel of 89 orthodontists (85 orthodontists and 4 postgraduates) from the same regions were empanelled. They evaluated the differences in facial aesthetics pre- and post-treatment of the 64 patients on a five-point scale in which −2 = markedly worsened, −1 = worsened, 0 = no change, +1 = improved, and +2 = markedly improved. The photographs of each patient were displayed for 15 seconds. In order to evaluate intra-individual reproducibility of the measuring system, six duplicate sets of patients were randomly inserted into the series.

Table 1 Distribution of patients over gender and Angle Classes.

	Class I	Class II division 1	Class II division 2	Class III	Total
Boys	7	9	8	8	32
Girls	8	9	8	7	32
Total	15	18	16	15	64

Statistical analysis

Statistical analysis was performed on the ratings of a final panel of 74 laymen and 87 orthodontists. The ratings of two laymen and two orthodontists were excluded because of missing data. The distribution of geographical region, gender, and age of both panels is given in Table 2.

Means and standard deviation (SD) of the ratings for each set of photographs were calculated per panel, per age, per gender, and per geographical region. The number of observations of laymen (74) and orthodontists (87) was large enough to consider the data normally distributed.

In the statistical evaluation of the reproducibility of the ratings on the five-point scale, the random error for a rater was calculated as $SD/\sqrt{2}$, with SD = the SD of the differences of the duplicated photographs.

Pearson's correlation coefficients were used to determine the individual reliability using the median of all raters for the six sets of duplicate measurements.

The influence of professional background, age, gender, and geographical region of the panel members on the five-point scale for boys and girls separately and their first order interactions were tested within the framework of multilevel models. Second-order and higher order interactions are difficult to interpret and therefore only the model with the four main effects and first-order interactions is presented. Analyses were performed, using 'Proc Mixed' in SAS 8.0 (SAS® Software, SAS Institute Inc., Cary, North Carolina, USA). For this purpose, age was dichotomized at 46 years, which was the median age of the panel members.

Table 2 Distribution of geographical region, gender (m = males, f = females), and age of laymen and orthodontists in the panels.

Panel members	*n*	Age (years)		
		Mean ± SD	Median	Range
Laymen				
Dutch	39 (23 m, 16 f)	53.9 ± 8.6	52	39–74
Belgian	35 (12 m, 23 f)	48.0 ± 10.7	47	28–76
Orthodontists				
Dutch	45 (28 m, 17 f)	46.7 ± 8.3	45	32–65
Belgian	42 (9 m, 33 f)	37.3 ± 6.4	38	25–53

A two-way analysis of variance (ANOVA) was performed on the mean ratings of laymen and orthodontists separately, in order to evaluate the effect of gender and Angle Class of the patients on the ratings.

The reliability for the final score was expressed as the intraclass correlation coefficient (ICC). The subjects (adolescents) were entered as a random effect in the analysis. Variance of the random effects, V_b, is the between-subjects variance and reflects the variability of the five-point score between subjects. The within-subject variance, V_w, reflects the variability of the panel members over the same subject. The ICC is then given by $V_b/[V_b+V_w]$, which can be interpreted as the mean correlation of randomly selected pairs of single panel members. The ICC is 1 when all panel members agree perfectly on all subjects. When the within-subject variance is large (panel members substantially disagree on the same subject) compared with the between-subjects variance, the ICC is close to 0. The five-point score can be considered to be a reliable measure if the ICC is equal to or above 0.80. When the five-point score is based on the average five-point scores of N randomly selected raters, the ICC for pairs of panels is $ICC(N)=N\times ICC(1)/[1+(N-1)\times ICC(1)]$.

The optimal panel size was found by choosing the smallest value of N where ICC(N) was equal to or above 0.80 for girls as well as for boys.

Results

All mean scores were normally distributed. Means and SDs of the five-point scores for boys and girls, given by laymen and orthodontists, young (under 46 years) and old (46 years and over) panel members, males and females, and Dutch and Belgian panel members are shown in Table 3.

The random errors for the different photographs varied over the laymen from 0.5 to 0.8 points and over the orthodontists from 0.4 to 0.7 points. The mean of the differences of the duplicate measurements varied from –0.8 to 0.4 and –0.6 to 0.8, respectively.

Table 3 Means and standard deviations (SDs) of the scores on the five-point scale for the photographs of boys, girls, and boys and girls taken together, given by laymen and orthodontists, young (under 46 years) and old (46 years and over) panel members, males and females, and Dutch and Belgian panel members.

Panel members	*n*	Mean five-point scores ± SDs		
		Boys	Girls	Both
Laymen	74	0.43 ± 0.25	0.51 ± 0.29	0.47 ± 0.25
Orthodontists	87	0.37 ± 0.22	0.51 ± 0.22	0.44 ± 0.21
Young	85	0.37 ± 0.21	0.51 ± 0.21	0.44 ± 0.19
Old	76	0.43 ± 0.25	0.51 ± 0.30	0.47 ± 0.26
Males	72	0.42 ± 0.23	0.49 ± 0.26	0.45 ± 0.23
Females	89	0.37 ± 0.24	0.53 ± 0.24	0.45 ± 0.23
Dutch	84	0.47 ± 0.20	0.55 ± 0.25	0.51 ± 0.21
Belgian	77	0.31 ± 0.24	0.47 ± 0.25	0.39 ± 0.23

The median correlation coefficient (individual reliability) was 0.69 (P25 = 0.39, P75 = 0.82) for the laymen and 0.87 (P25 = 0.75, P75 = 0.93) for the orthodontists.

The influence of professional background, age, gender, and geographical region on the five-point scale for boys and girls is shown in Table 4. Significant differences were observed for older, female, and Dutch laymen, who found more facial aesthetic improvement after orthodontic treatment in boys than comparable orthodontists. Younger panel members evaluated the change in facial aesthetics in boys and girls the same as older panel members. Lay females and Dutch females found more facial aesthetic improvement in girls than comparable males. Dutch panel members found more facial aesthetic improvement in boys than Belgian panel members. In girls, this finding was significant for lay, older, and female Dutch panel members.

For the boys, significant first-order interactions were found between professional background and gender (P = 0.03), professional background and region (P = 0.04), professional background and age of the raters ($P < 0.01$), region and gender ($P < 0.01$), and region and age of the raters ($P < 0.05$). For the girls, significant first-order interactions were found between region and professional background (P = 0.03) and between region and age of the raters (P = 0.02).

Two-way ANOVA showed no interactions between gender and Angle Class of the adolescents (interaction tests for both panels $P > 0.13$). There was no difference in the mean change in facial aesthetics between the boys and girls, and therefore, their data were combined for evaluation of the influence of Angle Class. Both panels scored a significant improvement after orthodontic treatment for Class I, Class II division 1, and Class II division 2 patients (all $P < 0.002$). Class III patients did not significantly improve ($P > 0.20$ for both panels; Table 5).

The ICC for two panels, each consisting of one randomly selected layman, judging boys was 0.34 and 0.22 in judging girls. The ICC for two panels, each consisting of one

Table 4 Difference of five-point means in a multilevel model with all mean effects. The *P* values are corrected for multiple testing (Tukey–Kramer).

	Boys		Girls	
	Difference in five-point score	*P* value	Difference in five-point score	*P* value
Laymen–orthodontists				
Young	–0.02	0.91	–0.01	0.99
Old	0.13	<0.01	0.03	0.83
Males	0.005	1.00	–0.03	0.78
Females	0.11	<0.01	0.05	0.38
Belgian	0.004	1.00	–0.05	0.53
Dutch	0.11	<0.01	0.07	0.14
Old–young				
Laymen	0.07	0.19	–0.001	1.00
Orthodontists	–0.09	0.09	–0.04	0.64
Males	–0.003	1.00	–0.04	0.69
Females	–0.01	0.98	–0.003	1.00
Belgian	–0.06	0.38	–0.09	0.14
Dutch	0.04	0.52	0.04	0.58
Males–females				
Laymen	–0.05	0.33	–0.12	<0.01
Orthodontists	0.05	0.45	–0.03	0.82
Young	–0.007	1.00	–0.05	0.39
Old	0.002	1.00	–0.09	0.07
Belgian	0.07	0.22	–0.06	0.36
Dutch	–0.07	0.10	–0.09	0.04
Belgian–Dutch				
Laymen	–0.22	<0.01	–0.17	<0.01
Orthodontists	–0.11	0.01	–0.05	0.54
Young	–0.11	<0.01	–0.05	0.50
Old	–0.22	<0.01	–0.18	<0.01
Males	–0.10	<0.05	–0.10	0.07
Females	–0.24	<0.01	–0.13	<0.01

Table 5 Mean improvement and standard deviation (±SD) of facial aesthetics over the Angle Classes (pooled data for boys and girls) as assessed by laymen and orthodontists.

Panel	Class I	Class II division 1	Class II division 2	Class III
Laymen	0.56±0.46*	0.68±0.50*	0.47±0.40*	0.14±0.46
Orthodontists	0.42±0.46*	0.64±0.60*	0.51±0.45*	0.14±0.39

*=Significant improvement $P<0.002$.

randomly selected orthodontist, when judging boys was 0.38 and 0.32 when judging girls (Table 6). The ICC was higher for the orthodontists than for the laymen. As V_w was considerably smaller for orthodontists than laymen, the orthodontists agreed more over the same adolescent than the laymen (Table 6).

The ICCs for panels with varying size are shown in Table 7. A panel of nine randomly selected orthodontists, a panel of 14 randomly selected laymen, or a mixed panel of 13 laymen and orthodontists fulfil the prerequisite of an ICC equal or above 0.80 both for boys and girls. These panel sizes are sufficient to obtain reliable results in the evaluation of the aesthetic change in adolescent faces, using photographs and a five-point scale.

Table 6 Between-subject variance, V_b, and within-subject variance, V_w, for laymen and orthodontists in the evaluation of changes in facial aesthetics of boys and girls and intraclass correlation coefficient (ICC) between two panels, each consisting of one randomly selected rater.

	V_b	V_w	ICC
Boys			
Laymen	0.29	0.56	0.34
Orthodontists	0.27	0.44	0.38
Girls			
Laymen	0.17	0.58	0.22
Orthodontists	0.22	0.46	0.32

Discussion

The lay panel in the present study was composed of males and females with a relatively high socio-economic status. This was justified since orthodontic treatment demand is higher in groups with a higher socio-economic status than in those with a lower status, whereas the objective treatment need is similar in both groups (Wheeler *et al.*, 1994). Therefore, such a lay panel can be assumed to be representative for the general public most concerned with orthodontic treatment demand.

Since the average treatment duration in the Department of Orthodontics, Radboud University Nijmegen, is approximately 3.3 years, the treatment duration of the patients was up to 3.3 years. The findings of this study must be seen as a change brought about by a combination of orthodontic treatment and growth, since it is impossible to analyse these two separately.

In this study, laymen and orthodontists saw an aesthetic improvement following orthodontic treatment in Class I, Class II division 1, and Class II division 2 patients. This aesthetic improvement was significant. However, it should be borne in mind that this improvement was only significant at the group level and not for each individual. As shown in Table 5, the mean improvements seen in Class I, Class II division 1, and Class II division 2 patients were in the range of 0.42–0.68 points. Whether this value is clinically relevant is subjective. As suggested by McComb *et al.* (1996), the expectations of parents of patients and of referring dentists are over-optimistic. Therefore, orthodontists should be aware of the fact that dentists expectations of patients and their parents can only be fulfilled to a certain degree. Especially for Class III patients, in which no significant improvement of facial aesthetics after treatment was found, orthodontists should be cautious with promises of aesthetic improvement.

Table 7 Intraclass correlation coefficients (ICC) for panels of sizes 5–15, for boys and girls separate for laymen, orthodontists, and for mixed panels.

Panel size	5	6	7	8	9	10	11	12	13	14	15
ICC for boys											
Mixed	0.69	0.73	0.76	0.78	0.80	0.82	0.83	0.84	0.85	0.86	0.87
Laymen	0.72	0.76	0.78	0.80	0.82	0.84	0.85	0.86	0.87	0.88	0.89
Orthodontist	0.75	0.79	0.81	0.83	0.85	0.86	0.87	0.88	0.89	0.90	0.90
ICC for girls											
Mixed	0.61	0.65	0.69	0.72	0.74	0.76	0.78	0.79	0.80	0.82	0.83
Laymen	0.59	0.63	0.67	0.70	0.72	0.74	0.76	0.78	0.79	0.80	0.81
Orthodontists	0.70	0.74	0.77	0.79	0.81	0.83	0.84	0.85	0.86	0.87	0.88

In a previous study (Kiekens *et al.*, 2007), in which the same laymen and orthodontists as in the present investigation were empanelled, the influence of panel characteristics on the aesthetic evaluation of males and females before treatment was investigated. However, comparison of the results of both studies is not justified, since in the present investigation the perception of change in facial aesthetics was evaluated, not the aesthetic preferences themselves.

In the present research, it was found that some subgroups of laymen, in judging boys, were more aware of aesthetic improvement than comparable subgroups of orthodontists. This is in contrast to the findings of Kerr and O'Donnell (1990). The panels used in that study, however, consisted of only four members. These panels may not be representative of the general public or of orthodontists and therefore their ratings should be considered with caution.

Dutch panel members found more aesthetic improvement after orthodontic treatment than Belgian panel members. All panel members in this study spoke the same language and lived in neighbouring countries. However, cultural differences between the countries exist and the finding from the present study might be an expression of such differences. Orthodontists working overseas must be aware of the fact that colleagues and patients and their parents from other countries might see more or less aesthetic improvement than themselves. Therefore, it is advocated that orthodontists working overseas communicate extensively with patients and their parents on their expectations of orthodontic treatment.

Panel characteristics have an influence on aesthetic evaluation. Differences in opinion were found in the different subgroups and several first-order interactions became apparent, indicating that the composition of a panel is extremely important in the evaluation of changes in facial aesthetics following orthodontic treatment. Therefore, it should be a major concern when comparing results of studies using different panels.

For evaluation of facial aesthetics, different panel sizes and different measurement techniques are found in the literature (Howells and Shaw, 1985; Dunlevy *et al.*, 1987; Kerr and O'Donnell, 1990; Phillips *et al.*, 1992; O'Neill *et al.*, 2000; Shelly *et al.*, 2000). It is surprising that so little is known on optimal panel size. If the optimal panel size is defined as the smallest panel that gives reliable results, calculation of the ICC is an appropriate tool. In the present study, the panel size was assumed to be optimal if the ICC was equal to or above 0.80. The use of smaller panels will lead to less reliable results, while the use of larger panels is unnecessary, more time-consuming, and more expensive.

Panel sizes of at least nine randomly selected orthodontists or 14 randomly selected laymen or a mixed panel of 13 raters are sufficient to yield reliable results, using a five-point scale as the outcome measure on change in facial aesthetics in adolescents. In a previous investigation on facial aesthetics, using a visual analogue scale as the outcome measure, it was found that a panel of seven randomly selected laymen and/or orthodontists could give reliable results (Kiekens *et al.*, 2007). This indicates that the optimal panel size is dependent on the measurement technique.

Conclusions

Professional background, age, gender, and geographical region of panel members have an influence on their evaluation of changes in facial aesthetics after orthodontic treatment. Panels with equal characteristics should be used for mutual comparison in different groups of patients.

Improvement of facial aesthetics after orthodontic treatment was seen in Class I, Class II division 1, and Class II division 2 patients.

In order to obtain reliable results of changes in facial aesthetics using photographs and a five-point scale, the panel should consist of at least nine randomly selected orthodontists, 14 randomly selected laymen, or if a mixed panel is used, it should consist of at least 13 members.

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