European Journal of Orthodontics 30 (2008) 515–520
doi:10.1093/ejo/cjn026
Advance Access publication 27 August 2008

The impact of orthodontic treatment on the quality of life in adolescents: a case–control study

Eduardo Bernabé*,**, Aubrey Sheiham**, Georgios Tsakos** and Cesar Messias de Oliveira**,***

*Unidad de Investigación en Salud Pública Dental, Departamento de Odontología Social, Universidad Peruana Cayetano Heredia, Perú, **Department of Epidemiology and Public Health, University College London and ***School of Dentistry, University of Manchester, UK

SUMMARY The aim of this case–controlled study was to assess the effect of orthodontic treatment on the quality of life of Brazilian adolescents. Two hundred and seventy-nine 'cases' (106 males and 173 females) and 558 controls (246 males and 312 females) were randomly selected from 15- to 16-year-old adolescents attending all secondary schools in Bauru, São Paulo, Brazil. A case was defined as having at least one condition-specific impact (CSI) attributed to malocclusion during the previous 6 months, based on the Oral Impact on Daily Performances index. Conversely, a control was defined as having no CSI attributed to malocclusion during the same period. Adolescents were also clinically examined for orthodontic treatment need using the Index of Orthodontic Treatment Need (IOTN) and asked about previous orthodontic treatment. Binary logistic regression was used for statistical analysis.

Females and adolescents with a definite normative orthodontic treatment need were more likely to report CSI than males and adolescents with no normative need [odds ratio (OR) = 1.48, 95 per cent confidence interval (CI) = 1.08–2.02 and OR = 2.02, 95 per cent CI = 2.09–4.47, respectively], whereas adolescents with a history of orthodontic treatment were less likely to report CSI than their counterparts (OR = 0.15, 95 per cent CI = 0.07–0.31). Furthermore, there was an interaction between a history of orthodontic treatment and the current level of normative need. Brazilian adolescents with a history of orthodontic treatment were less likely to have physical, psychological, and social impacts on their daily performances associated with malocclusion than those with no history of orthodontics. Gender was a confounding factor, whereas current level of normative orthodontic treatment need was an effect modifier. Prospective studies are needed to corroborate the present findings.

Introduction

The provision of dental care should be based on the ability to benefit an individual patient (Sheiham and Tsakos, 2007). The benefits of dental treatment must, therefore, be balanced against their associated risks and costs in order to safeguard individuals from procedures and interventions which may be of little benefit, or even harmful, and to avoid wasting limited financial resources (Shaw *et al.*, 1991). Interest in the effectiveness and the provision of orthodontic treatment has increased in recent years (Kerosuo *et al.*, 2000; Richmond *et al.*, 2004, 2005; Zhang *et al.*, 2006). Therefore, when evaluating orthodontic care is important to determine if treatment was appropriate and if the pre-treatment goals were achieved (Pietilä and Pietilä, 1996; Richmond *et al.*, 2004, 2005). With increasing emphasis on evidence-based health services, the need to document the impact of care is a challenge to the orthodontic profession (Lagerström *et al.*, 2000).

Traditionally, the aims of orthodontic treatment are to improve dental and oral health and aesthetics, thereby resulting in an improvement in psychosocial well-being (O'Brien *et al.*, 1998; Cunningham and Hunt, 2001; Hunt *et al.*, 2001; Klages *et al.*, 2006). However, a recent review concluded that conflicting evidence exists about the effects of malocclusion and its treatment on function, appearance, and social and psychological well-being (Zhang *et al.*, 2006). Neither the psychosocial effects of malocclusion nor the benefits of orthodontic treatment have been systematically corroborated (Shaw *et al.*, 1980, 1991; Albino *et al.*, 1994; Kenealy *et al.*, 2007). Moreover, there is a paucity of research investigating the effect of orthodontic treatment on patients' opinions and attitudes. It is important for orthodontists to know whether malocclusions affect dental health and/or psychosocial well-being (Shaw *et al.*, 1980, 1991) as, without such evidence, it is impossible to give patients accurate information during the consent process.

Therefore, there is a need for a more comprehensive and rigorous assessment of the impact of orthodontic treatment on quality of life, employing standardized, valid, and reliable instruments (Zhang *et al.*, 2006). Normative measures should be complemented by Oral Health-Related Quality of Life (OHRQoL) measures (O'Brien *et al.*, 1998; Kok *et al.*, 2004). An OHRQoL measure that is linked to specific conditions, such as malocclusion and/or conditions related to orthodontics, has the potential to provide an insight into the

physical, psychological, and social consequences of untreated malocclusions, as well as the benefits and side-effects of orthodontic treatment (O'Brien *et al.*, 1998; Cunningham and Hunt, 2001; Klages *et al.*, 2006). At present, the condition-specific feature of the Oral Impact on Daily Performances (OIDP) is one of the few OHRQoL measures specifically designed to attribute oral impacts to specific oral problems according to an individual subject's perception (Adulyanon and Sheiham, 1997). This makes the OIDP a useful tool in assessing oral health needs and prioritizing oral health care services (Gherunpong *et al.*, 2006a, b, c; Sheiham and Tsakos, 2007).

As there are relatively few studies on the benefits and side-effects of orthodontic treatment using a condition-specific OHRQoL, a case–control study was planned with the objective of assessing the impact of a history of orthodontic treatment on the quality of life of Brazilian adolescents. The hypothesis tested was that adolescents with a history of completed orthodontic treatment were less likely to report a condition-specific impact (CSI) attributed to malocclusion than their counterparts.

Subjects and methods

Ethical approval was obtained from the International Research Board at the University of São Paulo. All participants signed a consent form and none were under orthodontic treatment at the time of study.

One thousand six hundred and seventy-five 15- to 16-year-old adolescents attending all secondary schools in Bauru, São Paulo, Brazil were randomly selected and interviewed. Of the 1675, a final sample of 279 'cases' and 558 controls were examined clinically. A case was an adolescent with at least one CSI attributed to malocclusion during the previous 6 months, whereas a control was an adolescent without CSI attributed to malocclusion during the same period. A sample size calculation was undertaken to find an odds ratio (OR) of 0.50 between a history of orthodontics and the presence of CSI attributed to malocclusion, assuming a history of orthodontics in 10 per cent of the controls, with a 90 per cent power ($\beta = 0.10$) and at the 5 per cent level ($\alpha = 0.05$).

During the interviews, the adolescents provided information concerning demographic factors [gender, age, and socio-economic status (SES)] and the impact of their oral conditions on daily performance during the previous 6 months, using the OIDP. This index assesses serious oral impacts on eight daily performances, namely, eating, speaking, oral hygiene, relaxing, smiling, studying, emotion, and social contact. If adolescents reported an impact on any of the eight performances, the frequency of the impact (scale from 1 to 3) and the severity of its effect on daily life (scale from 1 to 3) were scored. If no impact was reported, then a score of 0 was assigned. Additionally, adolescents were asked to specify the oral problems that, in their opinion, caused the impact. Only those impacts related to the following conditions were considered as being attributed to malocclusion: 'bad position of teeth', 'space between teeth', and 'deformity of the mouth or face'. Performance scores for the condition-specific aspect of the OIDP were obtained by multiplying the corresponding frequency and severity scores. The overall OIDP score was the sum of the eight performance scores (ranging from 0 to 72) multiplied by 100 and divided by 72 (Adulyanon and Sheiham, 1997; Gherunpong *et al.*, 2004a). The prevalence of CSI on daily performances was then calculated as the percentage of adolescents with a CS-OIDP score higher than 0 (Gherunpong *et al.*, 2004a, b).

Case and control adolescents were clinically examined for normative orthodontic treatment need using the Dental Health Component of the Index of Orthodontic Treatment Need (IOTN) by one author (CMO), who had undergone training and calibration (inter- and intraexaminer reliability: weighted kappa 0.77 and 0.91, respectively). The highest scoring trait was used to assess treatment need. Each adolescent was then classified as having 'no need' (IOTN 1 or 2), 'moderate need' (IOTN 3), or 'definite need' (IOTN 4 or 5; Brook and Shaw, 1989). Finally, adolescents were asked about any history of orthodontic treatment, irrespective of the type of appliance used. Adolescents who had received and completed orthodontic treatment were considered 'treated', whereas those who had never received, or had received but not completed, their orthodontic treatment were considered 'untreated'.

Statistical analysis

Binary logistic regression analyses were used to investigate the association between a history of orthodontic treatment and covariates (gender, age, SES, and current level of orthodontic treatment need) and the probability of reporting CSI attributed to malocclusion during the previous 6 months. Multiple binary logistic regression analysis was then carried out to test the association between a history of orthodontic treatment and the presence of CSI, after controlling for covariates. This multivariable model (main effects model) did not take into account interaction terms (Hosmer and Lemeshow, 2000; Kleinbaum and Klein, 2002). The term 'confounder' describes a covariate that is associated with both the risk factor and the outcome. When both associations are present, then the relationship between the risk factor and the outcome is confounded, but if the association between the covariate and the outcome differs among levels of the risk factor, or depends in some way on the level of the covariate, then there is interaction between the covariate and the risk factor. The term 'effect modifier' describes a variable that interacts with a risk factor (Rothman and Greenland, 1998; Hosmer and Lemeshow, 2000). The procedure for adjusting for confounding is appropriate when there is no evidence of interaction (Hosmer and Lemeshow, 2000; Kleinbaum and Klein, 2002).

The next step was the construction of as many models as there were interactions detected, by adding one by one possible two- and three-factor interactions in the main effects model and including those that were statistically significant ($P < 0.05$). A log-likelihood ratio test for each model was used in the selection for the final multivariable model. Non-significant interaction terms were excluded. The main effect terms were also eliminated from the model during this evaluation, but no term was dropped from the model if it was included in a higher order interaction term (Hosmer and Lemeshow, 2000; Kleinbaum and Klein, 2002).

Results

The details of the cases and controls are presented in Table 1. The percentage of orthodontically treated adolescents was significantly higher among controls than among cases (25.1 versus 6.5 per cent, respectively, $P < 0.001$). However, there were also statistically significant differences between both groups in relation to SES and current level of orthodontic treatment need (Table 1).

There was a statistically significant association between a history of orthodontic treatment and the presence of CSI attributed to malocclusion in the unadjusted model ($P < 0.001$). A history of orthodontic treatment was a protective factor against reporting CSI attributed to malocclusion (Table 2). Furthermore, SES and current level of orthodontic treatment need were also significantly associated with the presence of CSI in the unadjusted model ($P = 0.004$ and $P < 0.001$, respectively).

Multiple binary logistic regression analysis was performed to assess the independent effect of a history of orthodontic treatment on the presence of CSI while controlling for covariates. When a multivariable analysis was carried out, only a history of orthodontic treatment, current level of need for orthodontic treatment, and gender reached statistical significance to enter the model. Accordingly, a main effects model was built by taking into account only these three explanatory variables (Table 2). The presence of interactions was explored after the main effects model was obtained. Two- and three-factor interactions were gradually added to this model and statistically tested. The only significant interaction on the presence of CSI was for a history of orthodontic treatment and current level of orthodontic treatment need ($P = 0.008$). Therefore, the final model included the main effects model and this two-factor interaction (Table 3).

Controlling for gender, ORs and their 95 per cent confidence intervals (CIs) were calculated for adolescents with no, moderate, and definite normative orthodontic treatment need among the treated and untreated groups as well as for the treated and untreated adolescents in the groups with no, moderate, and definite normative need (Table 4). Among adolescents with no current normative need, treated individuals were less likely to report CSI than those untreated (OR = 0.15, 95 per cent CI = 0.07–0.31). However, the same pattern was not found among adolescents with moderate or definite normative need ($P = 0.059$ and 0.516, respectively). In addition, treated and untreated adolescents with a current definite need had a higher probability of reporting a CSI than adolescents with no need (both $P < 0.001$), and this probability was higher among treated (OR = 24.43, 95 per cent CI = 4.81–124.06) than among untreated adolescents (OR = 3.06, 95 per cent CI = 2.09–4.47). However, there were no differences between adolescents with a current moderate need and those with no need, both among treated and untreated groups.

Discussion

The main finding of this study was that adolescents with a history of completed orthodontic treatment had fewer CSI on their daily lives attributable to malocclusion, than adolescents with no history of treatment. Overall, adolescents with a history of orthodontic treatment had an 85 per cent lower probability (OR = 0.15, 95 per cent CI = 0.07–0.31) of reporting CSI attributable to their current occlusal status than their counterparts, after controlling for covariates. This association was partly influenced by other variables, particularly gender and current level of normative orthodontic treatment need. Gender was a confounder, whereas current level of normative orthodontic treatment need was an effect modifier of the association between a history of orthodontic treatment and the presence of CSI.

Table 1 Baseline comparison between Brazilian adolescents with and without condition-specific impacts (CSI) attributed to malocclusion (cases and controls, respectively).

Factors	With CSI ($n = 279$)		Without CSI ($n = 558$)		*P* value
	n	%	*n*	%	
Gender					
Males	106	38.0	246	44.1	0.093
Females	173	62.0	312	55.9	
Age (years)					
15	183	65.6	369	66.1	0.877
16	96	34.4	189	33.9	
Socio-economic status					
Low	168	60.2	277	49.6	0.004
High	111	39.8	281	50.4	
History of orthodontics					
Treated	18	6.5	140	25.1	<0.001
Untreated	261	93.5	418	74.9	
Current normative orthodontic treatment need					
No need	116	41.6	360	64.5	
Moderate need	58	20.8	122	21.9	<0.001
Definite need	105	37.6	76	13.6	

Table 2 Factors associated with the presence of condition-specific impacts attributed to malocclusion in Brazilian adolescents (279 cases and 558 controls).

Factors	Unadjusted OR	95% CI	*P* value	Adjusted odds ratio	95% CI	*P* value
Gender						
Males	1.00			1.00		
Females	1.29	0.96–1.73	0.093	1.40	1.02–1.91	0.036
Age (years)						
15	1.00			1.00		
16	1.02	0.76–1.39	0.877	1.04	0.75–1.43	0.820
Socio-economic status						
Low	1.00			1.00		
High	0.65	0.49–0.87	0.004	0.87	0.63–1.19	0.373
History of orthodontics						
Untreated	1.00			1.00		
Treated	0.21	0.12–0.35	<0.001	0.27	0.16–0.46	<0.001
Current normative orthodontic treatment need						
No need	1.00			1.00		
Moderate need	1.48	1.01–2.15	0.043	1.32	0.90–1.93	0.162
Definite need	4.29	2.99–6.16	<0.001	3.51	2.42–5.10	<0.001

Table 3 Final multivariable model, including main effects and two-term interaction, to explain the presence of condition-specific impact attributed to malocclusion in Brazilian adolescents (279 cases and 558 controls).

Variables	Beta	Standard error	Adjusted OR	95% CI	*P* value
Female/males	0.39	0.16	1.48	1.08–2.02	0.015
Treated/untreated	−1.91	0.39	0.15	0.07–0.31	<0.001
Moderate need/ no need	0.19	0.21	1.21	0.81–1.81	0.358
Definite need/ no need	1.12	0.19	3.06	2.09–4.47	<0.001
Treated by moderate need	0.84	0.69	2.31	0.60–8.89	0.225
Treated by definite need	2.45	0.83	11.55	2.29–58.28	0.003
Constant	−1.04	0.15	—	—	<0.001

Table 4 Estimation of adjusted odds ratio (OR) for the effect of a previous history of orthodontic treatment and level of orthodontic treatment need in Brazilian adolescents.

Effect	Among	*n*	Adjusted OR	95% CI	*P* value
Untreated	No need	356	1.00		
Treated	No need	120	0.15	0.07–0.31	<0.001
Untreated	Moderate need	154	1.00		
Treated	Moderate need	26	0.34	0.11–1.04	0.059
Untreated	Definite need	169	1.00		
Treated	Definite need	12	1.61	0.38–6.78	0.516
No need	Untreated	356	1.00		
Moderate need	Untreated	120	1.21	0.81–1.80	0.363
Definite need	Untreated	154	3.06	2.09–4.47	<0.001
No need	Treated	26	1.00		
Moderate need	Treated	169	2.46	0.67–9.02	0.174
Definite need	Treated	12	24.43	4.81–124.06	<0.001

When there is an interaction term, the OR for one risk factor is usually evaluated within categories of other risk factors (Hosmer and Lemeshow, 2000). Therefore, ORs were estimated to explain the interaction between a history of orthodontic treatment and the current level of normative orthodontic treatment need (Table 4). Three main conclusions

could be drawn from this analysis. First, the protective effect of a history of orthodontic treatment on the presence of CSI attributed to malocclusion was found among adolescents with no current normative need, but not among those with a moderate or definite need. Second, adolescents with a definite normative need had a higher probability of reporting CSI than those with no need, among both treated and untreated groups. However, this pattern was less clear when adolescents with a moderate need were compared with those who had no need. Finally, treated adolescents with a definite normative need had a 24.43 times higher probability of reporting CSI than those with no need, whereas untreated adolescents with a definite need had only a 3.06 times higher probability of reporting CSI than those with no need. This finding suggests that despite being previously treated, some adolescents still had some physical, psychological, and/or social activities affected by their malocclusions. In fact, such adolescents experienced higher levels of CSI than their untreated counterparts, perhaps due to previous unsatisfactory orthodontic treatment. It is likely that this was a small number of subjects, however, as it would be expected that the prevalence of patients with a definite orthodontic treatment need after having completed orthodontic treatment would be very low in a population-based study (Table 4).

Although it has been argued that outcomes of orthodontic treatment are not always ideal (Tuominen *et al.*, 1995; Kerosuo *et al.*, 2000), it is also likely that the majority of orthodontically treated adolescents had poorer occlusions before, than after, treatment (Tuominen *et al.*, 1995). However, based on the present study design, it was impossible to know if that was the case for those adolescents who reported CSI despite having been treated previously.

There are some limitations to this study: firstly, information regarding a history of orthodontic treatment was collected through self-report rather than the evaluation of clinical records or notes from dental clinics. Although this may have an effect on the findings, reliable clinical records are not always easily obtainable. Furthermore, the quality of case records varies widely among dental professionals in Brazil, especially among general practitioners. A second limitation of this study was that there were no pre-treatment assessments to compare the occlusal status or the socio-dental impact experienced by adolescents. It has been recommended that the impact of orthodontic care should be assessed through experimental designs (Richmond *et al.*, 2004, 2005). However, such studies are complicated. First, certain effects of malocclusion and treatment may only become apparent later in life, and second some occlusal traits of particular interest to orthodontists are relatively uncommon. Therefore, it is difficult to obtain representative samples and to perform meaningful statistical analysis. Finally, randomized control trials cannot be readily applied in orthodontics. Apart from ethical aspects, patient compliance is essential for completing treatment and there would be nothing to prevent active and control cases from altering their status once the trial had begun (Shaw *et al.*, 1986). For all these reasons, case–control studies are a good alternative to generate hypotheses.

Since no longitudinal data on pre- and post-orthodontic treatment were available, it was not possible to assess the magnitude of change attributed to treatment. However, the present findings provide supportive evidence concerning the beneficial impact of orthodontic treatment on quality of life. Since this study is one of the first to assess the psychosocial impact of orthodontic treatment on daily life, further research is still required in order to validate the present results.

Conclusions

Adolescents who had completed orthodontic treatment were less likely to report CSI on their daily performances attributed to malocclusion than those who had not undergone treatment. The outcome was partly influenced by gender and the current level of orthodontic treatment need. Gender was a confounder, whereas current level of normative orthodontic treatment need was an effect modifier.

Address for correspondence

Dr Eduardo Bernabé
Department of Epidemiology and Public Health
University College London
1-19 Torrington Place
London WC1E 6BT
UK
E-mail: e.bernabe@ucl.ac.uk

Funding

Programme Alβan, the European Union Programme of High Level Scholarships for Latin America (E06D1000352PE).

References

Adulyanon S, Sheiham A 1997 Oral impact on daily performances. In: Slade G D (ed). Measuring oral health and quality of life. University of North Carolina, Chapel Hill, pp. 151–160

Albino J E, Lawrence S D, Tedesco L A 1994 Psychological and social effects of orthodontic treatment. Journal of Behavioral Medicine 17: 81–98

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

Cunningham S J, Hunt N P 2001 Quality of life and its importance in orthodontics. Journal of Orthodontics 28: 152–158

Gherunpong S, Tsakos G, Sheiham A 2004a Developing and evaluating an oral health-related quality of life index for children; the Child-OIDP. Community Dental Health 21: 161–169

Gherunpong S, Tsakos G, Sheiham A 2004b The prevalence and severity of oral impacts on daily performances in Thai primary school children. Health and Quality of Life Outcomes 2: 57

Gherunpong S, Sheiham A, Tsakos G 2006a A sociodental approach to assessing children's oral health needs: integrating an oral health-related quality of life (OHRQoL) measure into oral health service planning. Bulletin of the World Health Organization 84: 36–42

Gherunpong S, Tsakos G, Sheiham A 2006b A sociodental approach to assessing dental needs of children: concept and models. International Journal of Paediatric Dentistry 16: 81–88

Gherunpong S, Tsakos G, Sheiham A 2006c A socio-dental approach to assessing children's orthodontic needs. European Journal of Orthodontics 28: 393–399

Hosmer D W, Lemeshow S 2000 Applied logistic regression. John Wiley & Sons, New York, pp. 91–142

Hunt O, Hepper P, Johnston C, Stevenson M, Burden D 2001 Professional perceptions of the benefits of orthodontic treatment. European Journal of Orthodontics 23: 315–323

Kenealy P M, Kingdon A, Richmond S, Shaw W C 2007 The Cardiff dental study: a 20-year critical evaluation of the psychological health gain from orthodontic treatment. British Journal of Health Psychology 12: 17–49

Kerosuo H, Kerosuo E, Niemi M, Simola H 2000 The need for treatment and satisfaction with dental appearance among young Finnish adults with and without a history of orthodontic treatment. Journal of Orofacial and Orthopedics 61: 330–340

Klages U, Claus N, Wehrbein H, Zentner A 2006 Development of a questionnaire for assessment of the psychosocial impact of dental aesthetics in young adults. European Journal of Orthodontics 28: 103–111

Kleinbaum D G, Klein M 2002 Logistic regression—a self-learning text. Springer, New York, pp. 92–118

Kok Y V, Mageson P, Harradine N W, Sprod A J 2004 Comparing a quality of life measure and the Aesthetic Component of the Index of Orthodontic Treatment Need (IOTN) in assessing orthodontic treatment need and concern. Journal of Orthodontics 31: 312–318

Lagerström L, Stenvik A, Espeland L, Hallgren A 2000 Outcome of a scheme for orthodontic care: a comparison of untreated and treated 19-year-olds. Swedish Dental Journal 24: 49–57

O'Brien K, Kay L, Fox D, Mandall N 1998 Assessing oral health outcomes for orthodontics—measuring health status and quality of life. Community Dental Health 15: 22–26

Pietilä T, Pietilä I 1996 Dental appearance and orthodontic services assessed by 15-16-year-old adolescents in eastern Finland. Community Dental Health 13: 139–144

Richmond S, Phillips C J, Dunstan F, Daniels C, Durning P, Leahy F 2004 Evaluating the cost-effectiveness of orthodontic provision. Dental Update 31: 146–152

Richmond S, Dunstan F, Phillips C, Daniels C, Durning P, Leahy F 2005 Measuring the cost, effectiveness, and cost-effectiveness of orthodontic care. World Journal of Orthodontics 6: 161–170

Rothman K J, Greenland S 1998 Modern epidemiology. Lippincott-Raven Publishers, Philadelphia

Shaw W C, Addy M, Ray C 1980 Dental and social effects of malocclusion and effectiveness of orthodontic treatment: a review. Community Dentistry and Oral Epidemiology 8: 36–45

Shaw W C, O'Brien K D, Richmond S, Brook P 1991 Quality control in orthodontics: risk/benefit considerations. British Dental Journal 170: 33–37

Shaw W C, Addy M, Dummer P M, Ray C, Frude N 1986 Dental and social effects of malocclusion and effectiveness of orthodontic treatment: a strategy for investigation. Community Dentistry and Oral Epidemiology 14: 60–64

Sheiham A, Tsakos G 2007 Oral health needs assessments. In: Pine C, Harris R (eds) Community oral health. Quintessence Publishing Co. Limited, New Malden, pp. 59–79

Tuominen M L, Nyström M, Tuominen R J 1995 Subjective and objective orthodontic treatment need among orthodontically treated and untreated Finnish adolescents. Community Dentistry and Oral Epidemiology 23: 286–290

Zhang M, McGrath C, Hägg U 2006 The impact of malocclusion and its treatment on quality of life: a literature review. International Journal of Paediatric Dentistry 16: 381–387