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Predicting the outcome of twin block functional appliance treatment: a prospective study

Susi Caldwell* and Paul Cook**

Department of Orthodontics, *Withington Hospital, Manchester and **Leeds Dental Institute, Leeds, UK

SUMMARY A prospective study was undertaken to investigate the relationship between various measured pre-treatment parameters and the reduction in overjet achieved when using a twin block functional appliance.

Forty-three subjects were fitted with a twin block functional appliance, and a number of pre-treatment clinical and radiographic morphological features were recorded. The functional appliance wear was monitored for 6 months and any individual who did not co-operate with wear was excluded from the subsequent analysis.

Multiple regression analysis with stepwise inclusion was used to relate the percentage reduction in overjet achieved by functional appliance wear to any of the pre-treatment parameters. The data from 22 individuals was included in the final analysis.

The overbite and SNB angle were the most strongly related variables to percentage reduction in overjet. These were then used to construct a predictive equation for the expected percentage reduction in overjet:

Percentage reduction in overjet in 6 months = $132 + 4.9x_1 - 1.4x_2$,

where x_1 = overbite and x_2 = SNB.

The pre-treatment overbite was, in isolation, the most influential feature in predicting the percentage of overjet reduction.

Introduction

There are many types of functional appliance design available for use in the correction of Class II division 1 malocclusions. In the UK, an increasingly popular functional appliance is the twin block (Clark, 1982). The appliance consists of two units, an upper and lower, which position the mandible forwards through the use of interlocking occlusal bite blocks. The independent units facilitate speech and eating with the appliance in place, and it is claimed that this improves patient compliance and consequently increases treatment success (Trenouth, 1989; Witzig, 1990).

A limited number of studies have investigated the treatment effects and results that can be obtained with the twin block appliance (Clark, 1988; Trenouth, 1989), and these have been demonstrated by Clark (1995). Whilst the results from these cases are excellent, there appears to be a general lack of experimental data relating to this appliance type, which may discourage widespread acceptance.

Previous studies, using a number of other functional appliances, have demonstrated that there is a wide variation in success rates for treatment of Class II division 1 malocclusions (Korkhaus, 1960; Dickson, 1964; Ahlgren, 1972; Harvold, 1976; Cohen, 1981; Bishara and Ziaja, 1989; Bondevik, 1991). A number of factors, such as MMPA (Pancherz, 1979), SNB (Parkhouse, 1969), ANB difference (Ahlgren and Laurin, 1976), and growth (Cohen, 1981), have been investigated in relation to functional appliance treatment success. The tendency has been to study these features in isolation, rather than in combination, which is how the patient normally presents. It is postulated that as yet unidentified morphological features of a malocclusion may contribute to a successful treatment outcome.

The aim of this study was to determine whether there are any patient characteristics, measurable prior to treatment, that identify a case as one where the overjet can be reduced successfully using a twin block functional appliance. From this information, a predictive model for outcome of twin block appliance treatment could then be constructed.

Subjects and methods

Subjects

Forty-three consecutive individuals (20 males and 23 females), with an age range of 8.6–14.3 years (mean 12.1 years), were included in the study. These were patients who presented with a Class II division 1 malocclusion for treatment with a functional appliance. The inclusion criteria were:

1. Class II division 1 incisor relationship (British Standards Institute, 1983).
2. Overjet greater than 6 mm.
3. Written consent given by the parent/guardian.

A subject was excluded from the investigation if, before or during the study period, a lack of compliance in wearing the appliance was detected.

Variables

Clinical measurements were made of the standing height (cm), overjet (mm), overbite (mm), and molar relationship. The molar relationship was recorded in ¼ units from Angle's Class I. The patient's age was recorded in decimal form and an indication of the stage of puberty was ascertained using a personal development questionnaire (adapted from Proffit, 1993).

Routine pre-treatment cephalometric radiographs were obtained for all study participants. The landmarks were digitized twice by the same operator, with at least 48 hours between each tracing, and the measurements were based on the average values obtained (Gravely and Benzies, 1974). Six angular and one linear measurement were taken from each pre-treatment cephalogram (SNA, SNB, ANB, upper incisors to maxillary plane, lower incisors to mandibular plane, MMPA, and LFH).

Measurement error

The clinical and radiographic measurement techniques were assessed for systematic and random errors. Measurements were repeated on five individuals with 48 hours between recordings. In addition, the clinical measurements were repeated by more than one operator so that inter- and intra-examiner variability could be determined. The results were assessed for random errors using the coefficient of reliability and Dahlberg's formula (as suggested by Battagel, 1993). The systematic error was evaluated by performing a paired *t*-test between two observations.

There were no significant systematic errors associated with the techniques for clinical and radiographic measurements. The random errors for these techniques were within acceptable limits. For the radiographic measurements this was 0.27–0.91 degrees with a 95–99 per cent coefficient of reliability. The clinical measurement error was between 0 and 0.22 mm for the overjet and overbite measurements (coefficient of reliability 95–100 per cent), and up to 0.5 cm (92–98 per cent coefficient of reliability for the height measurements).

Methods

All participants were fitted with a twin block functional appliance of the design shown in Figure 1. The bite registration was taken using a bite stick, which gave a 4-mm vertical opening anteriorly and an edge-to-edge incisor relationship. In the posterior regions a minimum opening of 5 mm was obtained. The only modification made to the appliance design was if there was an anterior open bite. In this situation, the Adams' clasps were placed on the lower first molars and

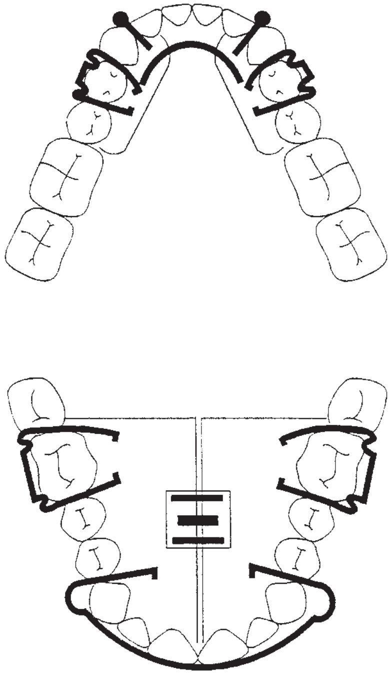

Figure 1 Twin block design for a subject with an average or increased overbite. Adams' clasps $\frac{6|6}{4|4}$ 0.7 mm stainless steel (ss); labial bow 3-|-3 0.7 mm ss; midline screw; ball-ended stops 3/2|2/3 0.7 mm ss; lingual bar. The lower acrylic should not touch the incisors or the lower molars. Upper and lower acrylic blocks with inclined planes at 45 degrees.

occlusal rests contacting the lower second molars. This prevented unwanted vertical development of these teeth.

All of the individuals were instructed to wear the appliance full time (24 hours per day, except during eating and contact sports) and their treatment was supervised by a number of different clinicians working at the Leeds Dental Institute.

Each participant was reviewed every 6 weeks for the study period of 6 months. At each visit, the individuals were questioned verbally with regard to appliance wear and the clinician recorded their impression. Those not fully complying with treatment were excluded from the study.

The amount of overjet reduction achieved in 6 months of twin block wear was recorded. A treatment was considered to be progressing successfully if the overjet had reduced by 50 per cent or 6 mm in 6 months.

Statistical analysis

Student's *t*-test and chi-squared tests were used to compare the groups of data included and excluded.

The amount of overjet reduction achieved in 6 months of functional appliance treatment may be associated with a number of the variables measured. Some of these were in the form of continuous and some categorical data. Multiple regression was used to analyse these data sets. The dependent variable was the reduction in overjet and the independent variables were the various characteristics measured.

The normal distribution of the dependent variable was confirmed using a box and whisker plot. This was necessary for the multiple regression analysis to be used effectively. The regression analysis was performed using the MINITAB statistical computer package, (Minitab Inc. State College, PA 16801–3008, USA). The data were then entered using stepwise inclusion of the variables; this calculates a partial regression coefficient for each variable selected and enables a predictive equation to be constructed. In addition, the extent to which independent variables explain the reduction in overjet was calculated as the coefficient of determination (R^2).

Results

Forty-three individuals commenced treatment with a twin block functional appliance, but only 22 wore the appliance as directed. These were subsequently included in the regression analysis, while those who were excluded formed a group of non-compliant patients. The data relating to these groups are shown in Table 1.

As a large proportion (49 per cent) of the original sample was excluded from the main study because of non-compliance with treatment, the possibility arose that the individuals remaining formed a biased sample. The results of the Student's *t*-test and chi-squared tests (Table 1) indicated that there did not appear to be any self-selection bias in any parameter tested

Table 1 The mean, standard error of the mean, and the results of the *t*-test for each set of variables. For the *P* values of Student's *t*-test there are 34 degrees of freedom.

Variable	Compliant $n = 22$ $x \pm$ SEM	Non-compliant $n = 21$ $x \pm$ SEM	*P* value for Student's *t*-test
Age	12.26 ± 0.26	12.06 ± 0.38	0.82
Height	151.64 ± 1.63	150.64 ± 3.15	0.76
Overjet	10.90 ± 0.40	10.61 ± 0.58	0.67
Overbite	4.64 ± 0.56	5.75 ± 0.50	0.17
SNA	81.65 ± 0.73	81.52 ± 0.75	0.91
SNB	75.99 ± 0.80	75.88 ± 0.81	0.93
ANB	5.88 ± 0.44	5.59 ± 0.53	0.69
UI–MxPl	115.49 ± 1.45	113.73 ± 1.75	0.45
LI–MdPl	88.89 ± 1.48	90.30 ± 1.64	0.54
MMPA	29.89 ± 1.26	27.66 ± 1.16	0.23
LFH	54.77 ± 0.50	54.43 ± 0.51	0.65

between the compliant and non-compliant groups.

Multiple regression with stepwise inclusion produced two model equations. The equations have a constant and each variable a partial regression coefficient associated with it. The coefficient of determination (R^2), expressed as a percentage, gives an estimate of how much of the overjet reduction can be explained by the combined variables:

Percentage reduction in overjet = $23.79 + 4.8x_1$

where x_1 = overbite and R^2 = 44 per cent, and

Percentage reduction in overjet = $132 + 4.9x_1 - 1.4x_2$

where x_1 = overbite, x_2 = SNB, and R^2 = 52 per cent.

The second equation is represented graphically (Figure 2) by plotting the actual overjet reduction achieved in 6 months for a particular subject against the overjet predicted by the equation, i.e. the expected versus the observed change in overjet. As the predictive precision of the equation increases, the results appear closer to the solid line illustrated. This hypothetical line represents where the observed reduction in overjet equals the expected. The figure shows that

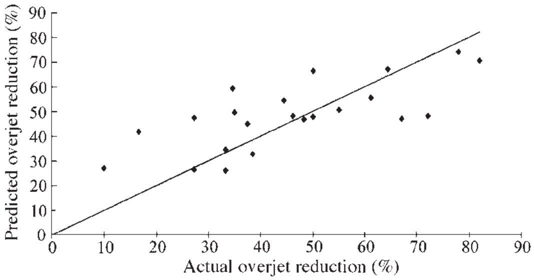

Figure 2 The actual overjet reduction achieved versus the overjet reduction using the predictive equation.

the equation tends to over predict the overjet reduction achieved, except at the higher end, where it under predicts.

Discussion

The results of this study show that there is a relationship between the reduction in overjet after 6 months of treatment with a twin block functional appliance and the morphological features measured pre-treatment. The most strongly related variables were overbite and the SNB angle. Using multiple regression with stepwise inclusion a predictive equation was produced:

Percentage reduction in overjet in 6 months = $132 + 4.9x_1 - 1.4x_2$

where: x_1 = overbite and x_2 = SNB.

The single feature that had the strongest relationship to overjet reduction was the overbite. The coefficient of determination for this variable as the single factor was 44 per cent and in combination with the other factor, SNB angle, rose to 52 per cent. The size of the coefficient of determination suggests that if overbite is assessed pre-treatment then it can act as a useful predictor of successful overjet reduction when employing twin block appliance therapy.

A 6-month time period was used in this study and the outcome assessed at this stage. This is not suggesting that treatment had been completed in this time, but was used to provide a useful focus for the clinician's attention, as reasonable progress should have been made within this period.

If, at the end of 6 months, adequate progress has not been achieved, the treatment plan should be re-evaluated. In the authors' opinion, during the first 6 months of functional appliance treatment, the overjet should show a significant reduction in the region of 6 mm or 50 per cent. If this is not evident, it is unlikely that continuing with this type of treatment will be successful.

In this study, 49 per cent of patients failed to wear the appliances as instructed. It would therefore be invaluable to be able to identify patient characteristics most strongly linked to co-operation. It is unlikely that poor co-operation will be totally eliminated, whilst most functional appliances can be removed by the patient. However, valuable time, finance, and future co-operation can be saved if, through the use of a predictive equation, successful cases could be identified.

A comparison of the current results with those of other workers is limited due to the lack of previous studies in this area. Charron (1989) analysed information gathered as part of a larger study relating to 35 patients who had undergone activator treatment for correction of a Class II malocclusion. Whilst the precise experimental methodology is, unfortunately, not given in that paper, a detailed description of the statistical analysis used is presented. Using a multiple regression analysis, the principle pre-treatment characteristics that were associated with overjet reduction were determined and a similar statistical technique to the present study was then used to measure the variables to obtain a predictive equation. Two equations were produced. The first showed the overbite and the height of the mandibular ramus as associated features, and the second the motivation of the patient and the height of the mandibular ramus. The accuracy of the equations in that study was in the region of 63 per cent, which is slightly greater than those demonstrated in the current study.

The overbite is the only variable that is a common finding to both studies. The height of the mandibular ramus was not measured in the current investigation. The method which Charron (Charron, 1989) used to obtain this measurement is not entirely clear, but it is open to particular criticism as the two points used to locate the mandibular ramus height are not easily determined.

Bondevik (1991) investigated two parameters, co-operation and pubertal growth spurt, and their predictive value in a retrospective study of 78 cases. Co-operation emerged as the only variable useful in predicting treatment results, but this is difficult to measure objectively, particularly in a retrospective study, and considerable bias may have been introduced. The other feature considered was pubertal growth spurt, an assessment of which was made with the aid of hand–wrist radiographs. Neither this nor the alternative method of growth assessments carried out in the current study, stage of pubertal development, standing height, or chronological age, revealed any association with successful treatment outcome. However, Cohen (1981) retrospectively compared unsuccessfully and successfully treated Andresen appliance cases. He reported that the more successful cases were undergoing facial growth during the period of their treatment. All the patients in the current study were increasing in stature and, therefore, presumably undergoing facial growth. There was no association between the velocity of increase in height and treatment outcome.

Previously, emphasis has been placed on the lower face height and the maxillary–mandibular plane angle (MMPA), and their relationship to functional appliance treatment outcome. The authors found no relationship between successful treatment outcome and either of these measurements of the vertical dimension. The size of the MMPA and its lack of influence on treatment outcome has been demonstrated by Pancherz (1979). In that study, he also refers to the degree of overbite and the treatment outcome, mentioning that an open bite (negative overbite) would result in a worsening of the overjet. The relationship between overbite and treatment results was not investigated further.

The relationship found in the current study and that of Charron (1989) could be explained if the presence of an increased overbite is an indicator of an inherent pattern of upward and forward growth rotation. This type of growth rotation is favourable when correcting a Class II malocclusion and the use of a functional appliance in these cases may allow the full expression of this direction of mandibular growth, which might otherwise not occur. In subjects with an open bite or lack of overbite the reverse may be true and this could be indicative of an inherent adverse growth rotation.

Another possible explanation for the strong association between overbite and overjet reduction may be that when a functional appliance is made for a patient with a deep overbite, the amount of vertical opening is greater than for a subject with a reduced overbite. The associated increased muscle stretch that accompanies this may result in an increased force being generated that is transmitted via the appliance to the dentition and skeletal structures.

The other characteristic that the current study associated with treatment success was the SNB angle. In isolation, this factor was not significant in treatment outcome, but together with the overbite influenced the reduction in overjet.

The statistical analysis indicated that the SNB angle has a negative relationship with the reduction in overjet, thus the smaller the SNB angle pre-treatment the more successful overjet reduction becomes. Individuals with a small SNB will posture the mandible further forwards to achieve an edge-to-edge incisor relationship. This increased muscle stretch may enhance the appliance's effectiveness. The size of the SNB angle has previously been implicated as an important factor during treatment. Parkhouse (1969) demonstrated that subjects with large ANB differences at the start of activator treatment had a two-fold increase in SNB value during treatment compared with those with a smaller ANB difference initially.

The graphical representation (Figure 2) of the actual overjet reduction achieved against the overjet reduction predicted by the equation, demonstrates the degree of accuracy of the equation produced by this study. The accuracy for predictive purposes is reasonable in the middle of the range, but at the extremes it is much less reliable. Further work is needed to improve the accuracy of the equation and to identify other features, which will strengthen the prediction.

Conclusions

The association of a deep overbite pre-treatment with successful overjet reduction during functional appliance treatment, was found in both the current study and that of Charron (1989). This association is a new and important step forward. The previously favoured vertical measurements of LFH and MMPA were not found to show a strong association with a successful reduction in overjet.

1. In those individuals who wear the appliance, the main pre-treatment feature of value when predicting functional appliance treatment outcome is the overbite.
2. The predictive equation has highlighted one further parameter: SNB. This confirms current clinical decisions of cases in which twin block functional appliance treatment might be successful.
3. This present study confirms that co-operation remains a problem in removable functional appliance treatment.
4. The predictive equation produced by this study has a co-efficient of determination of 52 per cent. For a clinically useful prediction equation, further work is required to improve the accuracy of the equation. This may be provided by increasing the sample size and including features that were not considered by this study.

Address for correspondence

Mrs S. Caldwell
Orthodontic Department
Withington Hospital
Nell Lane
Manchester M20 2LR, UK

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References

Ahlgren J 1972 A longitudinal clinical and cephalometric study of 50 malocclusion cases treated with activator appliances. Transactions of the European Orthodontic Society, pp. 285–293

Ahlgren J, Laurin C 1976 Late results of activator treatment: a cephalometric study. British Journal of Orthodontics 3: 181–187

Battagel J M 1993 A comparative assessment of cephalometric errors. European Journal of Orthodontics 15: 305–314

Bishara S E, Ziaja R R 1989 Functional appliances: a review. American Journal of Orthodontics and Dentofacial Orthopedics 95: 250–258

Bondevik O 1991 How effective is the combined activator–headgear treatment? European Journal of Orthodontics 13: 482–485

British Standards Institute 1983 Glossary of dental terms (BS4492). British Standards Institute, London

Charron C 1989 Recherche d'elements pronostiques quant a l'effecacite de l'Activateur en occlusion de classe II d'Angle. Orthodontie Française 60: 685–693

Clark W J 1982 The twin block traction technique. European Journal of Orthodontics 4: 129–138

Clark W J 1988 The twin block technique. A functional orthopedic appliance system. American Journal of Orthodontics and Dentofacial Orthopedics 93: 1–18

Clark W J 1995 Twin block functional therapy. Applications in dentofacial orthopedics. Mosby–Wolfe, St Louis

Cohen A M 1981 A study of Class II division 1 malocclusions treated by the Andresen appliance. British Journal of Orthodontics 8: 159–163

Dickson G C 1964 A survey of 100 cases treated with the Andresen appliance. Transactions of the British Society for the Study of Orthodontics, pp. 93–96

Gravely J F, Benzies P M 1974 The clinical significance of tracing error in cephalometry. British Journal of Orthodontics 1: 95–101

Harvold E P 1976 The activator in interceptive orthodontics C V Mosby Co., St Louis

Korkhaus G 1960 Present orthodontic thought in Germany. American Journal of Orthodontics 46: 270–287

Pancherz H 1979 The mandibular plane angle in activator treatment. Angle Orthodontist 49: 11–20

Parkhouse R C 1969 A cephalometric appraisal of cases of Angle's Class II, division 1 malocclusion treated by the Andresen appliance. Transactions of the British Society for the Study of Orthodontics, pp. 61–70

Proffit W R 1993 Contemporary orthodontics, 2nd edn. C V Mosby Co., St Louis

Trenouth M J 1989 A functional appliance system for the correction of Class II relationships. British Journal of Orthodontics 6: 169–176

Witzig J 1990 Twin block—eight advantages of this amazing new functional appliance. Functional Orthodontist 7: 4–8