Predicting functional appliance treatment outcome in Class II malocclusions–a review

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Selecting cases suitable for treatment with a functional appliance remains a problem as much of the relevant literature is anecdotal. There are also design and methodologic differences between the available studies, and most studies are limited to the Andresen type of appliance. The literature suggests that functional appliances are most successful in cases with an overjet of up to 11 mm, an increased overbite, active facial growth, and good cooperation. (Am J Orthod Dentofac Orthop 1997;112:282-6.)

Functional appliances are removable or fixed orthodontic appliances that are held in contact with both upper and lower dental arches. The appliances hold the mandible in a postured position away from the normal rest position. The literature surrounding the use of functional appliances refers mainly to the Andresen type of removable activator functional appliance, and this article will refer to these, unless otherwise stated.

Several types of functional appliance are currently in use for the treatment of Class II, Division 1 malocclusions, but the results are variable and unpredictable. This has resulted in much controversy surrounding their use and an unwillingness of some orthodontists to commit themselves to a treatment modality of which the outcome appears so inconsistent. The controversy has not been eased by the claims of some enthusiasts concerning the mode by which the appliances have their effect and the range of cases that can be treated. These claims have not been supported by sound scientific evidence[1] but by case reports that draw impressive conclusions from weak clinical data. This is unfortunate, as good results can be achieved by using the appliances. However, the ability to routinely select cases that will result in a successful outcome is difficult because, although guidelines exist, they are anecdotal rather than supported by scientific evidence. In general the criteria used for case selection are similar to those proposed by Trenouth[2]:

1. A well-aligned lower arch.
2. A well-aligned upper arch.
3. A Class I-mild Class II skeletal pattern.
4. Forward posture of the mandible by the patient will give a satisfactory soft tissue profile.
5. A person who is undergoing active growth.

Indeed these criteria appear as a basis for undergraduate teaching in the United Kingdom.[3]

Difficulties also exist when trying to analyze results from the existing literature. The data relating to the different types of appliances tend to indicate that the effects and success rates are generally similar. However, the definitions of successful outcome encountered in previous studies are not consistent, so comparisons are difficult to make. At present, some publications[4] do not state by which criteria a result was deemed a success; others[5] indicate that an overjet below a certain measurement is successful. One study[6] uses such strict guidelines of the occlusal relationships that must be fulfilled it is surprising that any successful results were obtained. These methodologic differences between studies make comparisons difficult. This situation is increasingly problematic, as functional appliances are becoming a popular choice in the treatment of a malocclusion in two phases: first, correction of the sagittal discrepancy with a functional appliance, followed by full alignment with a fixed orthodontic appliance. The treatment aims of the first functional phase are to reduce the overjet and correct any molar relationship discrepancy. As the complete correction of the overjet may not be required if the treatment is to be carried out in two phases, the definition of success needs to be flexible enough to allow for these variations in treatment objectives.

Vargervik and Harvold[7] indicate that there is a wide individual variation in the response to treatment, even if broadly similar malocclusions are treated. Also, there are cases where the compliance is good but the results, in terms of overjet reduction, are disappointing.[6] In these cases, there may be morphologic differ-

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0889-5406/97/$5.00 + 0 8/1/70556

ences between the successful and unsuccessful groups, which lead to this anomaly. This current article aims to review the factors that have been proposed as playing an important role in functional appliance treatment outcome. These factors include patient compliance, facial growth, overjet, incisor angulation, vertical relationships between the jaws and the teeth, sagittal relationships, and dental alignment.

PATIENT COMPLIANCE

As with any treatment method, patient compliance is largely outside the control of the orthodontist. Bishara[8] suggested that the success of a functional appliance is totally dependent on cooperation. Ahlgren,[9] after the treatment of 50 consecutive cases with a functional appliance, also found that poor cooperation was one of the main reasons for failure of treatment. Bondevik[6] attempted to identify factors that influenced successful functional appliance treatment outcome by comparing satisfactory and unsatisfactory activator results. Cooperation, skeletal maturation, age, and sex were the variables considered and from these he found that cooperation was the only variable suitable for predicting the treatment outcome, good cooperation was associated with a satisfactory result. The investigation only considered a limited number of variables, and even among the most cooperative patients, there was only a 50% success rate. The study did not consider whether there were any morphologic features that could explain why the remaining 50% of cooperative patients should be unsuccessful in their treatment outcome.

In an attempt to elucidate the amount of time which patients actually wore their functional appliances, Sahm, Bartsch and Witt[10] studied a group who had had a microelectronic monitoring device embedded in their appliances. It was found that, on average, the appliances were being worn for 7.65 hours per day. This was only 50% to 60% of the time that the orthodontist had requested the patient to wear the appliance. The minimum amount of wear that results in successful treatment is not known. In view of this, instructing the patient to wear an appliance full-time would maximize the opportunity for success, especially if one can only expect the patient to wear the appliance for 50% of the instructed time. We did not draw any conclusions as to whether the number of hours that the functional appliances were worn in this study resulted in successful treatment.

FACIAL GROWTH

It is often stated that functional appliances are of greatest clinical benefit in the actively growing patient and have a limited role in the treatment of adults, who have completed their facial growth. This is supported by human and animal studies and by the absence of any data recording successful treatment outcome in nongrowing persons. It would appear that functional appliance therapy should be most successful during a period of rapid facial growth. Bjork,[11] found that as patients got older the effectiveness of functional appliances reduced. Broadbent and Golden[12] also stated that skeletal maturity influenced treatment outcome and recommended an assessment of this as part of orthodontic treatment planning. They stated that functional appliance treatment should be coordinated with maximum growth. This is supported by a study[13] involving adolescents treated with an Andresen appliance. The study demonstrated that those who had a more successful outcome were undergoing facial growth during the period of their treatment. The conclusion was that facial growth was a prerequisite for success. From the results of an animal study[14] involving Rhesus monkeys, McNamara concluded that protrusive functional appliances in nongrowing patients would result in treatment effects confined to the dentoalveolar area and any skeletal alterations would be minimal.

The small changes involved in facial growth are difficult to assess and its maximum velocity has been reported as occurring a few months after the peak velocity in stature.[15,16] This usually occurs between the ages of 10.5 and 14 years in girls, and 12.5 and 16 years in boys. The spurt in skeletal height occurring during adolescence could therefore be used as an indicator for timing of functional appliance treatment. Pancherz and Hägg[17] used this in their study of patients treated with a Herbst appliance. They found that there was an increased condylar growth response when the functional appliance treatment was carried out close to the period of most rapid growth in stature, the peak height velocity.

Attempts have been made to predict when the skeletal growth spurt will occur, but unfortunately no simple and reliable method, appropriate to orthodontics, has yet been devised. The two methods that have been used in orthodontics to predict the growth spurt are hand-wrist radiographs[18] and a prediction using repeated standing height measurements.[19] Unfortunately, there are problems associated with both methods. Houston[20] outlined those relating to hand-wrist radiographs, and when using the repeated height measurements technique, the large number of pretreatment visits required, make this method impracticable. In most cases, the clinician only has a single examination on which to base his judgement, and this technique requires a minimum of four visits over a 12-month time period.

The relationship between the physical changes of puberty and the timing of the growth spurt in height has also been investigated.[15,21] These studies found that, in female subjects, the growth spurt tends to begin early in relation to the other physical changes of puberty and, in male subjects, it occurs relatively late. It may therefore be possible to use the relationship between the increase in stature and the changes occurring during puberty to plan the start of functional appliance treatment. By using this approach the necessity of estimating the timing of the actual peak height velocity could be avoided.

OVERJET

Few investigators have studied the relationship between the size of the overjet before treatment and the treatment outcome. Dickson[4] studied 100 patients treated with an Andresen appliance. He found that those with the smallest overjet, less than 7 mm, at the beginning of treatment showed a 98% success rate, while those with a severe overjet (11 mm) only obtained a success rate of 55%. Although this appears to demonstrate a relationship between the magnitude of the pretreatment overjet and success in treatment, in the article it is stressed that these findings were limited as the study was retrospective and possibly biased.

In relation to long-term treatment outcome, Drage[22] investigated the size of the pretreatment overjet in relation to posttreatment relapse. She tried to determine whether any predictors of overjet relapse existed. Although a positive correlation between the magnitude of overjet reduction and the degree of posttreatment relapse was demonstrated, the correlation was weak.

INCISOR ANGULATION

It has been widely reported[23,24] that functional appliance treatment results in a change in incisor angulation. It may be possible that the initial angulations of both upper and lower incisors are of importance in influencing treatment outcome, as these features are closely related to the mechanism by which the functional appliances work. There have been no previous investigations into the relationship between the pretreatment angulation of the incisors relative to the maxillary or the mandibular plane and treatment outcome.

THE VERTICAL RELATIONSHIP

The vertical relationships between the maxilla, the mandible, and the dentition can be considered in a number of ways: the overbite, the maxillary-mandibular planes angle (MMPA), and the anterior facial height. All these factors can be measured clinically or from cephalometric radiographs.

Several authors have attempted to relate these pretreatment measurements to treatment outcome. Tulley[25] stated that treatment with an activator appliance is unsuccessful in cases with an open bite. He stated that, in these cases, growth is in a more downward than forward direction, which results in a worsening of the open bite rather than a reduction in the overjet. Pancherz[26] found some evidence that supported Tulley, in a study of the relationship between the MMPA and the treatment outcome. He reported that, in cases where there was an increased MMPA and an open bite before treatment, the open bite was exaggerated after therapy and a further deterioration of the sagittal relationship resulted. However, he also found that in the absence of an open bite, the overjet reduced equally well in cases with either a high or low pretreatment MMPA. He therefore concluded that the magnitude of the MMPA before therapy had no influence on the treatment outcome unless in conjunction with an open bite.

This suggests that although the MMPA may not influence treatment outcome, the degree of overbite may. This is supported by a study by Charron[27] that measured 47 morphologic variables on each of 35 patients treated with an activator appliance. With a multiple regression analysis, the pretreatment overbite and the vertical height of the mandibular ramus were identified as the features associated with a good prognosis for treatment outcome. These findings could be a reflection of an upward and forward growth pattern, which would be favorable for the correction of a Class II skeletal discrepancy.

There are appliance designs that are based on philosophies, which specifically address a vertical discrepancy, for example, the maxillary intrusion splint and the Teuscher appliance. However, data are not available to show that these appliances have greater treatment success than other functional appliances.

THE SAGITTAL RELATIONSHIP

The pretreatment sagittal relationship between the maxillary and mandibular dental bases may have an influence on treatment success. Parkhouse[28] demonstrated that the increase in the SNB angle, which occurred during functional appliance treatment, was double in his experimental group, which had a larger pretreatment ANB angle (mean ANB = 7.81°).

Ahlgren and Laurin[29] also demonstrated that the pretreatment ANB value was the only morphologic difference between groups successfully and unsuccessfully treated activator cases. The successfully treated group had a larger ANB angle before treatment than the unsuccessfully treated group. However, as this parameter was not highly significant between the two groups ($P > 0.01$) the authors believed that the skeletal form did not give information useful for selecting the right cases for functional appliance treatment.

A literature review[30] of data relating to changes in the sagittal relationship produced by functional appliance treatment has shown that many of the changes in the SNB values attributed to appliance treatment can also be observed in the control groups. This supports the view that normal mandibular growth can improve the sagittal skeletal relationship spontaneously in many cases,[31] it is not possible to predict which ones those will be.

DENTAL ALIGNMENT

As previously mentioned, Trenouth[2] described the generally accepted criteria for the successful treatment of Class II, Division 1 malocclusions. He stated that upper and lower arches should be well-aligned. There appears to be no scientific data to support this, just clinical experiences of authors[25] who had found functional appliance treatment most successful in patients with no potential crowding and with spaced and proclined upper incisors. The cases described were those in which the appliances acted as a single course of treatment. However, it is becoming increasingly popular for functional appliances to act as a first phase of treatment, in crowded Class II cases, to correct the sagittal discrepancy before fixed appliances to fully align the dentition. It is not known whether the appliances perform equally well in these crowded cases.

CONCLUSION

At present, it is not possible to select any clear-cut predictive parameters for the outcome of functional appliance treatment as there seems to be such a wide variation in method and design from one study to the another. From the information available in the literature at present, it would appear that the best chance of success would be to limit functional appliance treatment to patients who present with the following parameters:

1. a mild to moderate increase in overjet, up to 11 mm;
2. an increase in overbite;
3. active facial growth; and
4. a willingness to comply.

Difficulties may be encountered when treatment timing is related to the period of most active facial growth, during adolescence, as this can be a time of low compliance. Starting treatment earlier maybe an attractive proposition, as compliance may be better, but the rate of facial growth is less, and this could affect the treatment outcome. However, if treatment in female patients starts at age 10 to 11 years and in male patients at 11 to 12 years, before the patients are fully into adolescence, but the growth spurt has commenced, the problems of poor compliance can be overcome. The expected rate of overjet reduction during treatment is 1 mm per month, therefore as most of the functional appliance phase of treatment will be complete in 6 to 12 months, the main part of adolescence can be avoided.

It is accepted that clinicians will be able to show cases that were successful in outcome but did not fall within the previously mentioned guidelines. This highlights the need for further studies to identify those parameters that may be used to select the types of malocclusion that respond favorably to functional appliance treatment.

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