Is Early Treatment with Functional Appliances Worth the Effort? A Discussion of the Pros and Cons of Early Interceptive Treatment

Ib Leth Nielsen

Clinical Professor (Emeritus), Orofacial Sciences, Division of Orthodontics, University of California, San Francisco, USA, ibortho9@gmail.com

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Early treatment of Class II, Div. 1 malocclusion is a much debated approach and some evidence based studies using a single appliance concluded that this approach was often not worthwhile. This article will discuss the pros and cons of early treatment with functional appliances and present guidelines for early treatment. The role of facial growth and dentoalveolar development, and growth intensity will be discussed as they relate to treatment outcome. A retention protocol for early treatment with functional appliances will be suggested.

**Keywords:** Class II Div. 1 malocclusion; early treatment; functional appliances; facial growth; retention

One of the most common malocclusions treated in the orthodontic office is the Class II, Div. 1 that usually is present in combination with a deep bite. The majority of these malocclusions are skeletal and due to an increased sagittal jaw relationship. In the majority of the cases the maxilla in its normal position but the mandible is retrognathic.

Over the years there has been a large number of different functional appliances available that in general have been used for treatment in the mixed dentition. These appliances were mostly developed in Europe and became popular primarily because they were removable and therefor did not contribute to further increase in the caries frequency that in many European countries at the time was a major problem. In the USA these appliances have only to some degree been accepted and never gained the same acceptance as they have in the European countries. Many different designs have been used over the years (Figure 1).

There has been much discussion in recent years about whether or not the Class II, Div. 1 malocclusion should be treated in the early mixed dentition or later when all teeth have erupted for both financial and practical reasons. The effectiveness of early treatment...
complicated and the results of these cost benefit studies, where functional appliances were used, are questionable. We therefore feel that the topic deserves more attention than it has been given in recent years. In this article we will attempt to clarify some of the issues around early treatment of the Class II, Div.1 malocclusion to hopefully bring some clarification to the topic. It should also be helpful to establish some guidelines for when to treat early and in which case treatment can be postponed until all teeth have erupted.

In patients with a Class II, Div. 1 malocclusions and a deep bite there are several important factors that must be assessed before any treatment decisions can be made. One very important thing to keep in mind is that during the early and late mixed dentition stages the sagittal jaw relationship does not generally change as illustrated in Figure 2. The severity of the malocclusion will of course vary from patient to patient, but in the more severe cases, where the overjet is greater than 7 mm there is a significantly higher risk of traumatic damage to

Figure 1. Different types of functional appliances. (A) The Harvold Woodside Activator. (B) The Andresen appliance. (C) The Fränkel II appliance. (D) The Teuscher Headgear-Activator appliance. (E) The Bass appliance. (F) The Bionator (Balters).
the incisors which would be a strong indication for early treatment.

An additional concern is that a deep bite, often seen in cases with Class II malocclusion and an increased overjet, adds further challenge to the treatment and may in itself be an indication that early treatment is appropriate. This increase in overbite is mostly the result of over eruption of the lower incisors, as they normally keep erupting until they make contact with either the palatal mucosa or the gingival tissues behind the upper incisors. This deepening of the bite has been shown to get worse over time and often results in an impinging overbite. The worsening of the bite is a result of the anterior growth rotation of the mandible that most patients experience during growth. If, however, the lower incisors during their eruption make contact with the lingual surfaces of the upper incisors there is less of a chance that the overbite will deepen during growth, as this now becomes a “fulcrum point” that can resist the effects of the jaw rotation. In those cases, the malocclusion may not need to be corrected early but treatment can be delayed until all teeth have erupted. These are just some of the considerations that should be part of the final decision whether to treat early or late, but in individual case there may be other reasons to consider as well when deciding on the most appropriate time for treatment.

FURTHER CONSIDERATIONS ON EARLY TREATMENT

Delaying orthodontic treatment until all teeth have erupted, as recommended in some studies, presents the risk that the most active part of the growth period with the best chance for making a change in the jaw relationship has been missed, in those patients where this is an important consideration. It is not uncommon that dental maturation especially in girls is lagging behind their skeletal maturation, so by the time the teeth have all

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Figure 2. Composite tracings of 29 subjects with Class II, Div. 1 malocclusion observed over a period of three years without treatment. The jaw relationship did not improve nor did the overjet and overbite get better. In fact, when looking more closely it can be seen that the maxillary incisors became more proclined thereby increasing the overjet. This increase in proclination is undoubtedly due to dysfunction of the lower lip.
erupted, there is little or no growth left of the mandible and further change in the jaw relationship can not be obtained. This is particularly of concern in young Hispanic females where girls often are in their pubertal growth spurt around age ten and a half to eleven and where the bicuspids and canines typically often are barely erupting. Furthermore, there also are no second molars present yet, that should be included in the treatment. In other words, there are in some patient ethnic considerations needs to be included in the treatment planning of the individual patient’s orthodontic treatment.

It is important to mention to the parents before any treatment is begun, that a second phase of treatment may be needed later after all the teeth have erupted as it adds additional cost to treatment. However, when it is explained to the parents of a child that the facial change needed in their child’s case can only be achieved through early treatment, most parents will understand the situation, and agree to early treatment.

The choice of appliances for early treatment should preferably be based primarily on removable appliance with as little use of fixed appliances as possible, and if necessary only for a short time. This will further make it more acceptable to most parents when a second treatment phase with full fixed appliances later is needed, as it is a different approach that couldn’t be done earlier in the mixed dentition, and it also should be made clear that the goal for this second phase is different, as it focuses more on aligning of individual teeth to obtain an ideal bite.

**SOME THOUGHTS ON CHOICE TREATMENT OF MECHANICS**

When looking closely at the illustration, previously shown in Figure 2, one can notice that the maxillary molars during the observation period migrate mesially. This is in part due to forward growth of the maxilla, in part to mesial migration within the maxilla. This observation is an important detail as it demonstrates one of the main goals of functional appliance treatment, namely preventing the normal mesial migration of the upper posterior teeth in addition to restraining forward growth of the maxilla. Additionally, it is one of the goals of early or “interceptive” treatment to prevent further proclination of the upper incisors during the growth period. Most of these goals can be achieved by using fixed appliances and headgear, but in patients who are in the early mixed dentition this approach would be limited to a two by four fixed appliance combined with the headgear. Unfortunately, this approach does not address the common problem with lip dysfunction seen in these patients, and any fixed appliances increase the risk of caries especially in these young patients. Alternatively, a functional appliance can be used to achieve similar results and with several additional benefits to be discussed further in the following.

An approach that has been popular for many years for early interception of a Class II, Div. 1 malocclusion is to treat the malocclusion with a combination of a bite plate and headgear. The function of the bite plate is to correct the deep overbite, and the cervical headgear is intended to restrain forward growth of the maxilla, thereby correcting the Class II malocclusion. Although this appliance combination may work well in cases with very active facial growth and a favorable growth pattern, it can in some cases result in downward growth of the mandible (Figure 3). The increase in anterior facial height (AFH) has to be balanced by the increase of posterior facial height (PFH) for expression of sagittal mandibular growth (Figure 4).

In patients where limited growth intensity is expected this combination of appliances, headgear and bite plate, should in general not be used and other approaches with better control of the vertical component of AFH may be more useful. It is an unfortunate fact that the amount of condylar growth in a juvenile patient in general is unpredictable and that the annual growth of the condyles
Figure 3. Lateral cephalograms of a patient with a Class II, Div. 1 malocclusion and a deep bite, treated with headgear and bite plate. Patient’s mandible didn’t grow forward as expected but instead descended vertically, possibly caused by too much tooth eruption relative to the amount of vertical condylar growth during the treatment period. The lack of posterior tooth contact, resulting from the separation of the posterior teeth by the bite plate, permits too much eruption of both the upper and lower posterior teeth. The additional extrusive component of the cervical headgear adds to the problem with this undesirable result. Because of the appliance combination and the lack of posterior tooth contact, the anterior face height (AFH) increased in this patient more than the increase in posterior face height (PFH), which mostly is increased by condylar growth.

Figure 4. The components that make up the AFP and the PFH. The green arrow indicates the condylar growth component that together with lowering of the temporo- mandibular fossa during growth make up the PFH increase. The red arrow represents the sutural lowering of the maxilla that together with the eruption of the maxillary and mandibular molars (blue arrows) makes up the AFH change.
can vary from as little as 1mm to as much as 4-5 mm per year. The following graphs show these changes in subjects with untreated Class II malocclusion.  

The amounts of annual condylar growth in girls and boys during the juvenile growth period are seen in Figure 5. The subjects all had a Class II malocclusion and did not receive any treatment during the observation period. The average growth at the condyles is about 3-4 mm per year, with some individual variation; additionally, we found that the growth intensity fluctuates from year to year within each individual. These facts should be taken into consideration when planning treatment and discussing the estimated length of treatment with the patient’s parents. The fairly limited amount of growth during the juvenile period presents a further challenge namely that it necessitates good vertical control to reduce the eruption of the posterior teeth that otherwise could increase the AFH and prevent forward growth of the mandible.

### ADVANTAGES AND DISADVANTAGES OF FUNCTIONAL APPLIANCES

Functional appliance treatment has been used, as previously mentioned, especially in Europe for many years and quite successfully. It has also to some degree been used in the US with good results, but has lately fallen behind in comparison to fixed appliance treatment, especially in cases where early-interceptive treatment was especially indicated. Before we discuss the general function of these appliances it may be a good idea to review the advantages and disadvantages of functional appliances. As seen in Table 1, there are some positive

<table>
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<th>ADVANTAGES OF FUNCTIONAL APPLIANCES</th>
<th>DISADVANTAGES OF FUNCTIONAL APPLIANCES</th>
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<tr>
<td>Provide instantaneous improvement in lip function</td>
<td>Can only be used in growing individuals</td>
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<tr>
<td>Minimal risk of caries</td>
<td>Limited control of individual teeth</td>
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<tr>
<td>Can be used in the mixed dentition</td>
<td>Initial limited fixed appliance may be needed</td>
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<tr>
<td>Are primarily used at night</td>
<td>The appliances are often bulky and may interfere with speech</td>
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<tr>
<td>Minimal chair time for adjustment</td>
<td>Should not be used in mouth breathers</td>
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<td></td>
<td>Good patient cooperation is needed</td>
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**Figure 5.** Mean growth intensity for Swedish group of 32 (19 boys and 13 girls) untreated subjects with Class II malocclusion between the ages of 8 and 13 years. The average growth at the condyles is about 3-4 mm per year, with some individual variation.
and some negative issues relating to these appliances. A couple of important issues are listed that make these appliances preferable in patients with poor oral hygiene and concerns for caries.

One of the main advantages of functional appliances in comparison to fixed appliances is that these removable appliances are primarily used after school and at night, which may be an important consideration in some patients. A clinical advantage, not to be ignored, is that adjustments require very little chair time. An important benefit of functional appliances is that because of the forward postural position of the mandible it removes any possibility of lower lip dysfunction when the appliance is in the mouth, which can otherwise be a serious problem in patients with a large overjet. On the negative side it must be mentioned that these appliances do not work well in patients with speech problems and those that have airway problems and may require a less bulky appliance so as not to interfere with their breathing. Also, if there is severe crowding of the front teeth it may be more practical to treat with limited fixed appliances for short while, and as a separate step in treatment, before the functional appliance is inserted, to correct the skeletal part of the malocclusion.

**HOW DO FUNCTIONAL APPLIANCES WORK?**

Functional appliances are postural appliances that achieve their correction through muscle function. When the mandible is postured forward, and the patient bites into the appliance, the masticatory muscles are activated and want to retract the mandible back to its normal position. This activation of the muscles is transmitted through the appliances from the mandible to the maxilla and maxillary dentition.

The active force results in a combination of tooth movements and skeletal change with a restraining force on the maxilla that restricts its normal downward and forward growth and redirects this growth more vertically. This does not mean that sutural growth of the maxilla is stopped but instead it is changed in direction. The designs of the different functional appliances vary but in general they are constructed to prevent the normal mesial migration of the upper first molars (Figure 2), thereby allowing the mandibular molars to move forward relative to the upper molars with forward growth of the mandible. These appliances in most cases provide some degree of vertical control as there usually is acrylic between the upper and lower posterior teeth. In some instances, however, when there is a deep bite the acrylic over the lower teeth is removed to allow eruption of the lower posterior teeth so as to correct the overbite. It is a general misconception that a functional appliance in order to be effective has to provide extra forward growth of the mandible. The vertical and mesio-distal control of the upper posterior teeth and the restriction of maxillary forward growth in most cases are sufficient to correct the Class II and the overjet. It is important, to know that there are a number of functional appliances on the market, and that they all work pretty much the same way. Some of these are more sophisticated in their design than others, and therefore better suited to minimize undesirable side effects.

Side effects to be concerned with the functional appliances are posterior rotation of the maxilla, posterior rotation of the mandible, retroclination of maxillary incisors and proclination of mandibular incisors. Fortunately, newer designs including torquing springs, and capping of the lower and upper incisors have managed to get the inclinational changes under better control than in the early days of functional appliances. These side effects are summarized in Figure 6. By using torque springs against the incisors undesirable retro-clination of the maxillary incisors can be prevented. Our study of the *Teuscher Headgear Activator* appliance however, showed that the original design of the springs was not adequate in controlling the torque, so they needed to be changed. Instead we have since used a design by Dr. N. Bass that we have found to provide adequate control of this torque problem (Figure 7 A and B).
POSSIBLE SIDE EFFECTS OF FUNCTIONAL APPLIANCES
- Posterior rotation of the maxilla
- Posterior rotation of the mandible
- Retroclination of maxillary incisors
- Proclination of mandibular incisors

Figure 6. Superimposition of lateral cephalogram tracing shows better control of upper and lower incisors with a Teuscher appliance.

Figure 7. The Teuscher appliance (A) and the Bass appliance (B) with torque springs against maxillary incisors.
Any proclination of the lower incisors, that may prevent full correction of the Class II and the overjet, can be avoided by capping of the lower incisors. In the Teuscher Appliance, by covering both the upper and lower incisors labially with about 2 mm of acrylic proclination could be prevented. The results of our study of this appliance showed that in a sample of 40 patients change in lower incisor inclination was within a range of ± 5 degrees. We also found when we correlated the initial inclination of the lower incisors with their post treatment inclination that there was an inverse correlation between their initial inclination and the post treatment inclination suggesting that proclined teeth can upright during treatment and retroclined teeth can become more proclined. This finding is contrary to what previous studies have reported, where they concluded that it was a contraindication to use functional appliances in patients with proclined incisors.

The posterior rotation tendency, as measured by the mandibular plane angle, that has been reported with functional appliances, did not happen in our study. Correlating the pre-treatment mandibular inclination with post treatment showed no significant change. A summary of the linear and angular changes of the incisors in 40 patients during treatment with the Teuscher appliance is seen in Figure 8. Note the amount of forward growth of the mandible in this 18 months’ period and the lack of mesial migration of the upper molars that are effectively held back by the appliance. It is also important to notice that the maxillary incisors, on average and despite the use of torque springs, as recommended by Teuscher, became more retroclined during treatment, whereas the lower incisors on average maintained their inclination with very little individual variation.

![Figure 8. Composite tracings of 40 patients treated with the Teuscher appliances. The linear and angular changes of the incisors during treatment with the Teuscher appliance](image)
An interesting aspect of the studies that looked at the cost benefit of early treatment was that it was of little or no benefit as discussed earlier in this article. It should be mentioned that in those studies there was no initial preparation of the dental arches prior to the insertion of the functional appliance. This is a different protocol from what has been used in Europe for instance where the dental arches nearly always are set up with initial maxillary expansion, retroclination of the lower incisors and proclination of the upper incisors. This is to prepare the arches for the functional appliance so that full correction of the molar occlusion can take place and to ensure adequate arch width that will make it possible to finish with a good occlusion in all three planes of space. When this is not done, the correction can only be partially successful and the patient is often left with a half cusp Class II malocclusion and a partially corrected overbite and no overjet, making a second phase of treatment necessary. Two such appliances that are used in developing the arches are seen in Figure 9. Maxillary Hawley retainers with expansion crews in the middle can increase the maxillary dental arch width. There are also two overlapping finger springs that permit proclination of the maxillary incisors when needed. Finally, the appliance has a bite plane to assist in correction of the overbite. These appliances have an additional purpose namely that they work as “training devices,” one might say. Using a retainer first, has and added benefit, as it tends to increase the cooperation of the patient later when the functional appliance is to be used as in most patients it makes it easier to get used to the somewhat larger functional appliance.

**CHOOSING THE RIGHT APPLIANCE DESIGN**

The choice of appliance for early treatment should be dictated by the need to control several factors listed previously in Table 1. If it is important to prevent retroclination of the maxillary incisors then torque springs can be added, if not a conventional labial bow may be the right choice. Having a headgear as part of the

![Figure 9](image.png) **Figure 9.** Maxillary Hawley retainers with expansion crews in the middle to increase the maxillary dental arch width (1-2 turns per week). A, there are also two overlapping finger springs that permit proclination of the maxillary incisors when needed. B, the appliance has a bite plane to assist in correction of the deep overbite.
appliance, as in the Teuscher appliance, has the additional advantage that it helps the patient keep the appliance in place and connected to the upper dental arch, which can be a problem if the patient sleeps with the mouth open. The combination of the high-pull headgear and activator further acts as a splint headgear should the patient not bite into the appliance during sleep. Other functional appliance without headgear do not have this advantage and the postural effect, that activates the masticatory muscles, is therefore not present when the patient does not bite into the appliance. As mentioned previously, these appliances in general can be used in the mixed dentition because they can be adjusted when deciduous teeth are lost. An added benefit of early treatment is that patients in the mixed dentition often are more cooperative than later and this gives these appliances a better chance to work. It is of course very important to monitor the progress of ongoing treatment that can be done by measuring the overjet at each visit. One should expect a 2-3 mm decrease over the first 6-8 weeks that is not uncommon. After that 1-2 mm per month can be expected, however, if there is no change between visits cooperation should be reviewed with the patient and the parents. This change in overjet is usually a combination of dento-alveolar change and growth changes.

TREATMENT WITH THE TEUSCHER APPLIANCE

In Figures 10 and 11, an early treatment with a Teuscher appliance demonstrates the effectiveness of this appliance combination in a patient in the early mixed dentition.

Figure 10. Pretreatment photos and cephalometric tracing of an 8 yr. 4 mos. old boy with a Class II, Div. 1 malocclusion and a deep overbite. Note the position of the lower lip.
Ib Leth Nielsen

overjet and overbite so that milder cases can be delayed until most permanent teeth have erupted, whereas severe cases should be intercepted early.

The type of functional appliance used should be dictated by the need to control the factors that can interfere with correction of the occlusion. Transverse and vertical correction with either a retainer or limited fixed appliance should be used in most cases which precede treatment with the functional appliance in order to develop the arches and to allow maximum occlusal correction and achieve a more stable occlusion.

It seems clear from the available data that in cases with excessive overjet and a deep overbite it is indicated to treat the malocclusion in the early mixed dentition to prevent permanent damage to the soft tissues in the palate by the deep bite and to reduce the risk for trauma to the maxillary incisors. Where the Class II is more moderate and the overjet less than 6 mm, the deep bite is not impinging and there is no need for skeletal correction, treatment may be postponed until the permanent teeth have erupted.

RETENTION

When the occlusion, the overjet and deep bite have been corrected it is important not to discontinue treatment right away, but to maintain the functional appliance use at night to avoid relapse. This is an important point that often has been overlooked when it seems the initial malocclusion is corrected. A minimum of six months is in most cases needed to ensure a stable occlusion. It is also important to make sure the patient is not posturing forward as extended use of a functional appliance can promote this tendency due to muscle conditioning from using the appliance over a period of time.

CONCLUSION

In conclusion, we know from many years of experience that Class II, Div. 1 malocclusions combined with deep bite can successfully be treated in the early mixed dentition with the use of functional appliances. Timing of treatment should be dictated by the extent of overjet and overbite so that milder cases can be delayed until most permanent teeth have erupted, whereas severe cases should be intercepted early.

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Figure 11. Post treatment photos and superimpositions after treatment with the Teuscher appliance. Treatment time 2 yrs. 4 mos.
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