The Early Management of Class III Malocclusions using Protraction Headgear

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Abstract: Class III malocclusions affect approximately 3% of Caucasians. Treatment options include; growth modification, dental camouflage and, once growth has ceased, orthognathic surgery. Originally, Class III malocclusions were thought to arise primarily from an overdevelopment of the mandible, but it is now known that maxillary retrusion contributes in up to 60% of cases. Maxillary retrusion is best treated with a combination of protraction headgear and rapid maxillary expansion, preferably before the age of 9 years. This article provides an overview of the management of skeletal Class III cases using protraction headgear with particular guidance for the general dental practitioner on when and how to treat.

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Clinical Relevance: Early use of protraction headgear in skeletal Class III cases not only addresses the aetiology of the malocclusion, but also reduces the need for comprehensive treatment later on.

Historically, skeletal class III relationships were thought to result primarily from over-development of the mandible. More recently, however, several authors have reported maxillary retrusion (Figures 1 and 2) to be the most common contributing factor, affecting up to 60% of all cases.[1,2] In addition to the anteroposterior discrepancy, Class III malocclusions also frequently display an anterior or posterior crossbite.[3]

The incidence of Class III malocclusions in the Caucasian population, in the United Kingdom and Scandinavia, has been estimated at 3-5%.[4] This may be increased to as high as 14% in Japanese and Chinese populations.[5]

Enlow (1982) describes the typical Class III individual as exhibiting a short middle cranial fossa and anterior cranial base.[6] The ramus is often rotated forward and the gonial angle is more obtuse; this increases overall mandibular length and steeps the mandibular plane angle, resulting in an increased lower anterior face height. The combination of these anatomic features, together with dentoalveolar compensations (maxillary incisor proclination and mandibular incisor retroclination), contributes to the overall Class III appearance (Figures 3, 4 and 5).

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OPTIONS FOR TREATING CLASS III MALOCCLUSIONS

Treatment options for skeletal Class III malocclusions include: growth modification, dental camouflage or orthognathic surgery, once growth has ceased. Typically, growth modification has been aimed at young patients with the use of such appliances as the chin cup, protraction headgear, or the functional regulator.[7,8,9,10]

The utilization of chin cups, unfortunately, has resulted in limited stability. Latent mandibular growth and a return to the pre-treatment condition are common deleterious sequelae.[11,12]

Previous studies have, however, demonstrated that Class III malocclusions treated in the deciduous dentition using functional appliances can produce significant effects on the direction of condylar growth and, consequently, on mandibular size and shape.[13,14]

Another option, dental camouflage, typically consists of using class III elastics following extraction of maxillary second premolars and mandibular first premolars, although a technique of employing anterior labial root torque and tying the wire forward in an attempt to advance A point has also been described.[15] However, this may lead to seriously compromised facial aesthetics and affect future treatment mechanics should an individual grow unfavourably and hence require orthognathic surgery.

As it has been established that maxillary retrusion is a significant component to skeletal Class III malocclusions, it would seem appropriate to direct treatment towards the maxilla. The preferred treatment for patients with skeletal maxillary retrusion is anterior movement of the maxilla using protraction headgear, ideally in combination with rapid maxillary expansion.[16] This has been reported to be most beneficial before the age of 8, before the posterior maxillary sutures have closed.[17]

TREATMENT INDICATIONS

The facemask is most effective in the

Figure 1. *Flattening in the paranasal region in a child with maxillary hypoplasia – front view.*

Figure 2. *Flattening in the paranasal region in a child with maxillary hypoplasia – profile view.*

treatment of skeletal Class III malocclusions with a retrusive maxilla and a hypodivergent jaw growth pattern. Patients presenting initially with some degree of anterior mandibular shift and a moderate overbite have an improved treatment prognosis. Correction of the anterior crossbite and mandibular shift results in a downwards and backwards rotation of the mandible that reduces the prognathism of the mandible and the presence of an overbite helps to maintain the immediate dental correction after treatment. However, before embarking on protraction therapy one must consider a multitude of factors, such as the severity of the malocclusion, patient compliance and their growth potential.[18]

PROTRACTION ALONE VERSUS PROTRACTION WITH RAPID MAXILLARY EXPANSION

Numerous authors have reported on the anterior constriction of the maxilla when it is protracted and emphasize the necessity of physically expanding the maxilla before protraction.[19,20,21] Palatal expansion alone has also been shown to facilitate correction of a Class III malocclusion by causing a downward and forward displacement of the maxilla.[22] Palatal expansion has been noted not only to affect the intermaxillary suture, but also all of the circum-maxillary articulations.[23] It has also been suggested that palatal expansion 'disarticulates' the maxilla, initiating a cellular response which then allows a more positive reaction to protraction forces.[24] An additional mechanism has also been proposed which involves structures some distance from the circum-maxillary suture system. In a study on rhesus monkeys, rapid maxillary expansion produced 0.5–1.0 mm of opening of the spheno-occipital synchondrosis, which led the authors to consider that this too might be a factor.[25]

Several authors have questioned the ability of rapid maxillary expansion to readily displace A point anteriorly.[26,27] Many of the sutures affected by protraction headgear are the same as those affected by maxillary expansion. In particular, the zygomatic buttress, especially the zygomatic suture, has been implicated as a major resistance to forces generated by both palatal and maxillary expansion.[28] One study divided a group of 60 patients who had had protraction facemask therapy into 47 who had had concomitant rapid maxillary expansion and 13 patients who had not. They found significantly greater forward movement of the maxilla when protraction was used in

Figure 3. *Mild skeletal Class III malocclusion – front view.*

Figure 4. *Mild skeletal Class III malocclusion – profile view.*

Figure 5. *Lateral cephalometric radiograph of a mild skeletal Class III malocclusion.*

Figure 6. *Protraction headgear showing; metal framework, forehead pad, chin pad and anterior elastics – front view.*

Figure 7. *Protraction headgear showing; metal framework, forehead pad, chin pad and anterior elastics – 3/4 view.*

conjunction with rapid maxillary expansion (2.0 mm with rapid maxillary expansion and 0.9 mm without) and therefore concluded that it is beneficial.[29] A recent study, involving a meta-analysis on 440 articles relating to Class III malocclusion, confirmed that maxillary protraction, in combination with an initial period of expansion, provides more significant skeletal effects than protraction alone.[18]

In addition to the skeletal effects, studies involving dental casts have shown increases in both maxillary intercanine and intermolar widths where expansion has been used.[30] Reports on concomitant expansion in the mandibular arch have not, however, been as consistent, although one study, reporting on a group of 20 Southern Chinese patients, was able to show a significant increase in mandibular intermolar width (by 2.3 mm) which remained stable after one year.[31] The increase in molar width may, however, be related to the anteroposterior change from a Class III to a more Class I skeletal relationship. In a Class III malocclusion, the anterior portion of the maxillary arch occludes on a wider portion of the mandibular arch, sometimes producing a posterior crossbite and/or compensating lingual inclination of the posterior maxillary and mandibular molars. Forward protraction of the maxilla produces a Class I skeletal relationship and buccal uprighting of the posterior molars, leading to an increase in posterior molar width.[32] Alternatively, stability of mandibular arch width after maxillary expansion may be due to the altered muscular response exerted on the dentition by the buccinator muscles, which have been carried laterally by maxillary expansion or by altered forces of occlusion.[33]

In summary, it has been shown that rapid maxillary expansion with maxillary protraction can lead to anterior movement of A point and correction of a maxillary, and possibly mandibular, transverse discrepancy (relative or absolute), both of which are beneficial.

APPLIANCE COMPONENTS

The Protraction Facemask

The use of a protraction facemask was first described more than 100 years ago,[34] with other descriptions appearing early this century. Delaire *et al.*,[8] revived interest in this technique with Petit later modifying the basic concepts of Delaire by increasing the amount of force generated by the appliance and thus decreasing overall treatment time.[9]

The Petit facemask was originally constructed on a patient-by-patient basis, using 0.25 inch round lengths of stainless steel wire, to which pads for the forehead and chin were then attached. Later, the design was simplified and made commercially available.

The commercial design is relatively simple consisting of a framework, or single midline rod, to which is connected a forehead pad and a chin pad (Figures 6 and 7). Heavy 3oz elastics are then attached to a midline crossbow in the deciduous canine region. This causes maximum displacement of the maxilla with a minimal rotational effect.[35] Maxillary protraction generally requires 300-600 grams of force per side, depending upon the age of the patient.

The role of maxillary protraction is to:

- Eliminate a centric relation–centric occlusion discrepancy;
- Protract the maxilla;
- Advance the maxillary dentition;
- Tip the lower incisors lingually; and
- Encourage vertical mandibular development.

The Bonded Rapid Maxillary Splint

Several versions on a theme have been used which include: removable appliances, lingual arches, fixed appliances and quadhelixes.[36] Banded and bonded maxillary splints have, however, superseded the rest.[16] The bonded maxillary splint, used widely today, consists of an acrylic and wire expansion device with hooks

Figure 8. *Bonded maxillary splint on maxillary cast.*

extending buccally at the level of the first deciduous molars for attachment of elastics (Figure 8). The splint is cemented onto the posterior teeth, usually the Ds, Es and 6s, with either a chemically-cured or a light-cured glass ionomer cement. It should be activated once per day (preferably just before the child goes to bed) until the desired increase in transverse dimension has been achieved, after which time the screw is stabilized. In patients in whom no increase in transverse dimension is desired, the appliance should still be activated for 8-10 days prior to fitting the headgear in order to disrupt the maxillary suture system and hence promote maxillary protraction.

DIRECTION OF FORCE

Histological modifications in the zygomaticomaxillary suture vary after maxillary protraction according to the orientation of the force system applied.[37] Strain gauges and displacement transducers have been used on dry human skulls to show how the location of the applied maxillary protraction force affects the characteristics and transformation of the craniofacial complex.[20] Protraction forces applied parallel to the occlusal plane, at the level of the maxillary arch, have been shown to produce anterior rotation and a forward movement of the maxilla, unless a downward vector of protraction force is also applied, whereas protraction forces applied 10 mm above the Frankfort horizontal plane have been shown to produce posterior rotation with a forward movement of the maxilla. It has been suggested that effective forward displacement of the maxilla can be obtained clinically from a force applied 5 mm above the palatal plane.[20] This direction of force is extremely desirable if a rotation of the maxilla is indicated. However, in deep bite cases in which an opening of the bite is desired, a forward pull from the level of the maxillary arch with a concomitant anterior rotation of the maxilla is more appropriate. An *in vitro* study, using a three-dimensional finite element method, found that an anteriorly directed force applied to the buccal surface of the maxillary first molar with a downward pull from 45–30° to the occlusal plane gave the most translatory effect.[28]

TIMING OF TREATMENT

Several authors have reported on results of studies that were initiated in the deciduous dentition,[12,13,14,38] whilst others have described craniofacial changes induced by treatment in the mixed dentition.[39,40] According to McNamara,[41] the optimal time to begin Class III treatment is in the early mixed dentition, coincident with the eruption of the upper permanent incisors. Some authors advise that, for optimal orthopaedic results, treatment be initiated before the patient is 9 years old,[18,42] whilst others suggest that maxillary protraction and chincup therapy is effective throughout puberty and that orthopaedic effects on the dentofacial structures may even be possible in young girls as late as during the acceleration phase of the pubertal growth spurt.[43]

CHANGES AFTER TREATMENT

Clinically, Class III individuals present with a concave facial profile, a retrusive nasomaxillary area and a prominent lower third of the face. In addition, the lower lip is often protruded relative to the upper lip. The upper arch is usually much narrower than the lower, and the overjet and overbite can range from reduced to reversed. After 6 months of maxillary protraction treatment, the skeletal and soft tissue profiles have been shown to straighten and the posture of the lips improve.[31] The downward and backwards rotation of the mandible leads to some opening of the gonial angle and an increase in lower face height.[39] When a normal incisor relationship (overjet) is achieved this has a significant influence on the soft tissues overlying both incisors and leads to better lip competence and posture with a concomitant reduction in upper lip sulcus depth. Significant correlations have been found between the sagittal relationships of the skeletal and soft tissue profiles in both the maxilla and the mandible.[31]

STABILITY AFTER TREATMENT

Maxillary Protraction

Both animal and human studies have shown that the effects of maxillary protraction on the maxilla can remain stable for a period of 1-2 years post treatment.[44] It had been postulated that the long-term effect of treatment might be related to increased sutural activity at the posterior part of the maxilla.[45]

The degree of relapse has been shown to be negatively correlated with the length of stabilization.[46] However, patient factors also play a role. One study, reporting on a group of 51 children treated with protraction headgear and chin-cap therapy, found individual variation to be high with 43 children responding well to treatment and eight children poorly.[38] The group that responded poorly demonstrated a number of morphological characteristics including: a shorter cranial base, a more anteriorly positioned mandible, a more open mandibular angle and a more acute chin prominence. When these children were followed up one and a half years after treatment, the authors found that the size of the cranial base angle, the prominence of the chin and the size of

Figure 9. *Stabilized screw of bonded maxillary splint.*

Figure 10. *Anterior crossbite.*

Figure 11. *Corrected anterior crossbite.*

the inter-incisor angle all influenced the success of treatment.

Rapid Maxillary Expansion

Many studies have reported on the long-term stability of cases treated with rapid maxillary expansion, with the degree of relapse correlating to the degree of initial expansion.[47,48,49] A slow return to the pre-expansion arch shape has been shown to occur over time, with maxillary arches that were narrow initially or had lingually inclined molars tending to retain a greater percentage of their original expansion.[30]

PROTOCOL FOR THE MANAGEMENT OF PATIENTS WITH SKELETAL MAXILLARY RETRUSION

The effects of rapid maxillary expansion (RME) with protraction headgear are:

- Downward and forward movement of the maxilla and maxillary dentition.
- Downward and backward rotation of the mandible.
- Lingual tipping of the lower incisors.

The ideal case therefore exhibits:

- Mild skeletal discrepancy (ANB difference -1° to +2°).
- Upper labial segment which is of average inclination or upright.
- Lower labial segment which is of average inclination or proclined.
- Average or reduced lower face height.
- Average or, preferably, deep overbite.

1. Treat patients early, ideally around 8-9 years, either in the late deciduous or early mixed dentition (the ideal time being on eruption of the maxillary central incisors).
2. Fit a McNamara-type bonded RME splint first and activate once per day (preferably just before the child goes to bed) until the desired increase in transverse dimension has been achieved. Once the expansion is complete the screw should be stabilized (Figure 9). In patients in whom no increase in the transverse dimension is desired, still activate the appliance 8-10 days prior to fitting the headgear in order to disrupt the maxillary suture system and hence promote maxillary protraction.
3. Approximately 2 weeks later fit the protraction headgear. Use heavy 3oz elastics extending from hooks on the splint located adjacent to the upper first deciduous molars forwards onto the metal frame. Patients should wear the frame for as many hours as possible during the evening and at night.
4. Continue for 4-6 months, reviewing regularly, until there is a positive overjet and/or the deciduous canines are $^1/_2$ unit II bilaterally (Figures 10 and 11).
5. Take a lateral cephalometric radiograph post protraction-RME.
6. Once corrected, remove the splint and fit an upper removable appliance with a $^1/_2$ open screw to maintain the expansion (Figure 12). This may have hooks anteriorly to allow the patient to continue to wear their facemask at night (Figure 13).
7. One month later consider fitting a Frankel III functional appliance as a night-time retainer to maintain the anteroposterior correction (Figure 14).
8. Continue to monitor the skeletal relationship and occlusion as the individual grows.

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Figure 12. *Upper removable appliance with $^1/_2$ open screw on maxillary cast.*

Figure 13. *Upper removable appliance with hooks anteriorly for attachment of the protraction headgear.*

Figure 14. *Frankel III functional appliance.*

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ABSTRACT

OTHER COUNTRIES FIND ENDODONTICS DIFFICULT AS WELL

Quality Evaluation of Process of Root Canal Treatments Performed on Young Adults in Finnish Public Oral Health Service. S.E. Helminen, M. Vehkalahti, E. Kerosuo and H. Murtomaa. *Journal of Dentistry* 2000; **28:** 227-232.

The quality of endodontic treatment carried out in the United Kingdom has frequently been called into question. This paper presents the results of a survey carried out in Finland, with disturbingly similar conclusions.

The records relating to 148 root canal treatments carried out in general dental practice were examined. In 60% of the cases no reason was given for carrying out the endodontic treatment, and almost a quarter contained little clinical information regarding canal lengths, sizing, etc. Only 34% had a pre-operative radiograph, and only 52% had a post-operative film, in both of which almost one-fifth were not of a diagnostic quality. It was thus impossible to assess the quality of the treatment in over one half of the cases. In those where it was possible, 48% showed an unacceptable result. The authors had a list of criteria for optimal treatment, and not one case achieved a full score.

No reasons are postulated for the differences found between actual practice and clinical guidelines, but the authors conclude with the profound understatement that *the solution for how to overcome this gap would appear to be the master key to good quality root canal treatments.*

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