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## **Orthodontics**

Extra-oral appliances in orthodontic treatment

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## **Extra-oral appliances in orthodontic treatment**

### **Abstract**

Extra-oral oral appliances are used in orthodontics to apply forces to the jaws, dentition or both and the popularity of these appliances is cyclical. Although the use of retraction headgear for the management of Class II malocclusion has declined over the last 20 years with the refinement of non-compliance approaches including temporary anchorage devices, headgear still has a useful role in orthodontics. The use of protraction headgear has increased as more evidence of its effectiveness for the treatment of Class III malocclusion has become available. This paper describes the mechanics and contemporary uses of headgear in orthodontics for primary care dentists and specialist orthodontists.

### **Clinical relevance**

Extra-oral appliances have specific uses in orthodontic biomechanics. Clinicians using retraction headgear and protraction headgear should be familiar with their clinical indications, the potential problems and how these can be avoided.

### **Objective**

To develop the knowledge of the primary care dentist and specialist orthodontist in relation to extra-oral appliances in orthodontics.

## Extra-oral appliances in orthodontic treatment

### Introduction

Extra-oral forces used in orthodontic treatment require the use of headgear. After the introduction of retraction headgear by Norman W. Kingsley in the late 1800s, headgear use increased with the popularisation of the first generation of fixed appliances and retraction headgear by Edward H. Angle. Retraction headgear use reduced dramatically in the 1920s with the introduction of intraoral elastics as these were believed to provide equivalent forces (1). In the 1940s, the increasing use of cephalometric radiography in orthodontics led to concerns about the adverse effects of intraoral elastic traction including proclination of lower incisors and retroclination of upper incisors. As a result, headgear use increased again. Although the use of retraction headgear has declined steadily with the introduction of non-compliance fixed appliance distalising appliances including the pendulum appliance, lip bumper appliances and temporary anchorage devices (TADs), headgear remains the standard for anchorage reinforcement and maxillary arch distalisation. Enthusiasm is increasing for the use of protraction headgear for the treatment of Class III malocclusion and patients affected by hypodontia where space closure may result in a reverse overjet.

There are a variety of clinical uses for headgear, requiring different directions of forces, force levels and wear levels which result in varying effects on the dentition and/or skeletal base relationships. In this article, the contemporary uses and effectiveness of extra-oral traction appliances are discussed.

There are three main components:

1. **Extraoral unit:** This part of the appliance provides the anchorage for the extra-oral force in a form of headcap, neckpad/strap or chin cup (for retraction headgear) (Figure 1) or a facemask (for protraction headgear). Retraction headgear normally includes the delivery force system in the headcap / neckpad/strap.

2. **Force delivery system:** this can involve either a spring loaded device (Figure 2) or heavy-force extra-oral elastic. The former is used with retraction headgear and chin cup appliances while the latter is used with protraction facemask appliances.
3. **Intermediate / connecting component:** This transmits the force to the teeth and underlying skeleton and connects the extra-oral and intraoral components. With retraction headgear, the intermediate component is the outer part of the facebow that connects to the extra-oral component. The inner bow should also incorporate a robust safety mechanism to prevent an accidental disengagement (2, 3) (Figure 3a,b).
4. **Intraoral component:** Retraction headgear is attached via the headgear facebow to either fixed, removable or functional appliances for either anchorage reinforcement or molar distal movement. With a fixed appliance (Figure 4), the inner bow inserts to molar bands using welded headgear tubes which are either gingivally placed (close to the centre of tooth rotation) or occlusally positioned (for better access during insertion and removal). With removable appliances (Figure 5), the facebow either inserts into tubes soldered to the molar clasps or to coils wound as part of the clasps (Figure 3b). Headgear tubes can also be incorporated into the acrylic of a functional appliance for mid-arch orthopaedic force delivery. The only headgear appliance that has no intraoral component is the chin-cup appliances (4). When using a protraction facemask, the intraoral component is either a fixed or removable appliance with many operators simultaneously treating the patient with slow maxillary expansion (using a quad helix appliance) or rapid maxillary expansion (RME) (5, 6).

### **Uses of extra-oral appliance in clinical orthodontics**

The effectiveness of headgear depends on entirely patient compliance in wearing the appliance and it is well-known that patients usually overestimate the wear of headgear. (7) As headgear is not worn full-time, the intermittent force delivery is a biomechanical disadvantage with relapse occurring when the appliance is not worn. Headgear charts, timers and award systems have been proposed to improve compliance in order to improve

success rates. (8) There are different level of force and duration of use according to the clinical application. (Table 1)

### **1. Anchorage reinforcement**

Retraction headgear can be used for anchorage reinforcement antero-posteriorly and vertically. Although headgear is considered to be a good method of anchorage reinforcement, TADs have been shown to provide equivalent results with minimal patient co-operation (9). For anchorage reinforcement, force levels of 250-300g per side are required for a minimum of 10 hours/day, on average. (10-14).

### **2. Molar Distalisation:**

Retraction headgear can distalise the molars by up to ½ molar unit (approximately 5mm) which can be useful used for correction of a ½ unit Class II molar relationship and relief of crowding on a non-extraction basis or reduction of an increased overjet. (15-18). Molar distalisation using headgear in conjunction with extraction of the deciduous canine in order to provide space for ectopic permanent maxillary canines has been shown to have a success rate of 80% in comparison to 50% where the deciduous canine was extracted as an isolated measure (19). However, the Cochrane review by Parkin et al has shown there is no high-quality evidence to justify the interceptive effect of extraction of primary canines (20). Headgear can also be used to upright impacted upper first molars and to regain lost space after premature loss of primary teeth. (21). Force levels of 400-500g/side used over a period of 12-14 hours/day are necessary for distalisation. (10) Headgear use can tip and extrude the molars depending on the magnitude and direction of the applied force as well as the duration of headgear wear. (11-14).

### **3. Canine retraction/labial segment movement:**

J-hook headgear has historically been used to intrude upper anterior teeth, retract maxillary canines individually or rarely, retract lower canines. (22). Force levels of 250-300g per side are required for a minimum of 10 hours/day, on average. (10-14) Due to the risk of ocular trauma and as canine retraction is more easily achieved with sliding mechanics when using contemporary fixed appliances, J-hook headgear is no longer used.

### **4. Differential (asymmetric) tooth movement:**

Asymmetric movement of the molars can be achieved using asymmetrical headgear (AHG) (23). There are many designs for AHG but the main principle of action is Castagliano's Theorum which involves greater movement on one the side due to a longer outer bow or heavier force on this side. The variety of designs of AHG include the power-arm facebow, soldered-offset face-bow, swivel-offset face-bow and spring-attachment face-bow (24-26). One of the disadvantages of AHG is the tendency to produce a scissor bite on the side of the long arm and an increase in difficulty when fitting the appliance (27). Force levels of 250-300g per side are required for a minimum of 10 hours/day, on average. (10-14)

### **5. Growth modification**

a. Class II malocclusion: theoretically, headgear can alter the skeletal relationship, due to a restriction of maxillary forward and downward growth that allows the mandible to "catch up" during treatment, when used in growing children aged 12-13 years (28, 29). However, most of the skeletal improvement has been shown to be lost 1 year after treatment. (28, 30)

b. Class III malocclusion: Enthusiasm for the use of protraction facemask headgear for the treatment of cases with a Class III incisor relationship is increasing. Studies have found that the facemask may provide an orthopaedic effect in growing patients with an improvement in the ANB angle by an average of 2.6 degrees when compared to a control group. (31) Unlike the loss of the skeletal improvement with retraction headgear in Class II cases over time, the

skeletal results with protraction headgear are generally stable after 3 years of treatment. (31, 32) Although, investigators have found that relapse can occur up to 8.5 years after treatment (33) protraction facemask is now the treatment of choice for mild to moderate Class III malocclusions (34).

c. High-pull headgear combined with a twin block, monoblock or Dynamax appliance can be used to treat high angle class II malocclusions. (35) However, the evidence for the effect of headgear on the vertical dimension is weak as Oliveira et al found only a limited improvement in anterior open bite when treated with a palatal crib and headgear. (36). Force levels of 400-500g/side used over a period of 12-14 hours/day are necessary for a skeletal effect (10).

### **Headgear types**

Headgear is categorized according to the antero-posterior direction of pull: if the force is directed distally, then the headgear called retraction and where the force is mesially directed, it is called protraction headgear. Retraction headgear is also classified according to the direction of force above, at, or below the occlusal plane: high pull, straight/combination pull and low or cervical pull.

#### **I. Retraction headgear**

1. *Low-pull or cervical traction (figure 6a)*: This type of headgear is frequently referred to as cervical traction and is the most commonly used headgear appliance. (37) Cervical traction is used mainly for the correction of Class II malocclusion by restraining the forward and downward growth of the maxilla. (38) Cervical traction is believed to have an interaction with the growth of the mandible as well as extrusion of maxillary molars. (39) This latter effect results in a clockwise mandibular rotation thus cervical headgear is indicated mainly for growing children with a deep overbite and is contra-indicated in cases with vertical skeletal discrepancies and anterior open bites. (39, 40)



2. *Straight/combination pull (figure 6b)*: This is a hybrid of high pull and low pull, producing a pure distal movement without any extrusion or intrusion of the molars. (37) The forces are transmitted to the teeth through a combination of a head cap and a neck strap. (23)
3. *High occipital pull (figure 6c)*: High pull headgear produces forces that pass apically through the centre of resistance of the maxillary teeth and clinical investigations have demonstrated that high pull headgear can perform distal movement of the molars effectively. (4) With high pull headgear, it is possible to produce intrusive forces to the molars rather than extrusive forces, which can therefore help the correction of an anterior open bite. (39) Occipital headgear can also produce orthopaedic effects on the maxilla by restraining the vertical growth of the maxilla. (37) Although wearing high pull headgear can result in compensatory eruption of the mandibular molars, this is can be controlled by using a fixed lingual arch.

## **II. J-Hook:**

1. *High pull*: This type of headgear exerts an intrusive and distal action on the upper incisors which moves the teeth distally as well as gingivally. (37)
2. *Straight/combination pull*: This is used to retract mandibular or maxillary canines distally. However, the force vector can cause downward tipping of the incisors. (37)
3. *Low Pull*: This type of headgear extrudes and retracts the mandibular incisors to camouflage a Class III skeletal base relationship. (37). It is worth noting that the use of J-Hook headgear in the UK is obsolete due to safety concerns about potential ocular injuries.

## **III. Protraction Headgear (figures 7,8)**

This is also called a facemask or reverse headgear. Facemask therapy is an effective orthopaedic appliance for growing children in order to correct a Class III malocclusion through forward movement of the maxilla. (41) The results of treatment are better in the early mixed dentition than in the late mixed dentition. (42) In addition to the skeletal changes,

reverse headgear can result in dental compensation to assist with the correction of a reverse overjet or Class III malocclusion. (14, 43)

#### **IV. Chin-Cup**

Chin-cup therapy is used to correct Class III malocclusions in growing patients using forces ranging from 250-600 g per side for at least one year. Many researchers have found that chin-cup therapy has effects on mandibular protrusion through dental effects as well as redirecting, inhibiting or slowing condylar growth. (44, 45) However, as no forces are applied to the maxilla, cases with maxillary hypoplasia will not have any upregulation of maxillary growth when treated with a chin-cup appliance. As a result, chin-cup therapy is seldom used in the UK.

#### **Fitting and monitoring progress with headgear**

##### Retraction

The first step in fitting the retraction headgear involves selecting the correct facebow size. The inner bow should be 1.13mm while the outer bow is 1.45mm for maximum rigidity. The facebow should be set parallel to occlusal plane with slight expansion. The centre of bow should be slightly away and above the central incisor edge. The inner bow should follow the contour of lip and cheeks but not actively displacing them. Each side of the facebow must be adjusted to fit into the fixed appliance molar bands or removable appliance tubes/colis at one side at a time. If the molar are rotated then toe-in bends should be placed. The length of the outer bow, relationship to the centre of rotation, the direction of pull should be carefully adjusted to minimise distal crown tipping. All these factors are important in determining the force vectors and the net force. In particular, if the outer bow is positioned at the trifurcation point of molars, the result will be distal translocation of the molars (10,46).

##### Protraction

With protraction headgear, the fitting procedure starts with adjusting the cams (Figures 7,8) using the Allen key until they are 15 degrees below the occlusal plane. The elastics are

attached to the intraoral device and should be heavy enough to apply the required force at 30 degree angulation. It is preferable for the elastics to cross-over to avoid lip irritation. (31)

Monitoring progress with headgear appliances can be undertaken by asking the patient / parent about compliance, using compliance charts (8), assessing the ability of the patient to insert/remove the appliance, checking for physical signs of wear and tear, identifying positive tooth movement in comparison with pre-treatment study models/ cephalometry and detecting molar mobility.

Iatrogenic effects of retraction and protraction headgear and solutions to overcome these

There are many iatrogenic effects of extra-oral appliances. These are detailed in Table 2 with solutions that can be used to manage them.

### **Safety mechanisms for retraction headgear**

Many safety mechanisms are available to prevent ocular injuries resulting from retraction headgear. These include:

1. Safety release mechanisms where the headgear is designed to 'break-away' when excessive force is applied (Figure 2). (56)
2. Safety facebows such as locking mechanisms (Figure 3a) (Nitom Locking Facebow, Ortho Kinetics Corporation, Vista, Calif/GAC International Inc, Central Islip, NY) and recurved reverse entry inner bows. (2, 3)
3. Additional safety mechanics such as blunt ends and locating elastics. (2)
4. Masel ([www.masel.com](http://www.masel.com)) safety strap (rigid neck strap). (2)

The British Orthodontic Society ([www.bos.org.uk](http://www.bos.org.uk)) recommends at least two main safety mechanics are provided with each headgear appliance as well as informed, written and

verbal instructions being given to the patient. Along with these instructions, the patient should be given a clear demonstration of how to insert and remove the headgear. It is vital to inform the patient to ensure the safety mechanisms are in place during use. Patients should be advised to avoid wearing their headgear while playing sports and they should stop the use of the headgear and contact their orthodontist immediately if the headgear becomes detached during sleep. Moreover, the patient must be aware that if any eye injury associated with the headgear occurs, it must be treated as a medical emergency. Lastly, patients should be instructed to bring their headgear to each appointment and report any problems to their orthodontist. (51)

### **Conclusion**

Retraction headgear remains a useful appliance in contemporary clinical orthodontics. Protraction headgear has both an orthopaedic and orthodontic effect and is a useful appliance for young patients presenting with a Class III malocclusion.

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**Table 1: Force Duration and levels with extra-oral appliances**

	<b>Force levels (gram/side)</b>	<b>Duration (hour/per day)</b>
Anchorage	250-300	10
Tooth movement	300-350	12-14
Orthopaedic movement	450-600	14-16

**Table 2: Iatrogenic effects, frequency and solutions**

Iatrogenic effect	Frequency	Management
Pain due to heavy force levels	Common	<ul style="list-style-type: none"> <li>• Non-steroidal painkillers</li> </ul>
Increased risk of root resorption	Rare possibly with J-hook headgear	<ul style="list-style-type: none"> <li>• Monitor radiographically using long cone periapical radiographs.(47) F</li> <li>• force levels should be as low as possible over a short duration</li> </ul>
Trauma to the face and eye	Rare but serious consequences (ophthalmitis and blindness) (48, 49) due to accidental disengagement or recoiling injuries (50)	<p>Prevention through:</p> <ul style="list-style-type: none"> <li>• Demonstration of the safe use of the headgear to the patient and parent</li> <li>• Verbal and written instructions (51)</li> <li>• Incorporation of safety mechanisms</li> </ul>
Nickel allergy Contact dermatitis-type IV (delayed hypersensitivity)	30% of female and 3% of male patients undergoing orthodontic treatment. (52)	<ul style="list-style-type: none"> <li>• Confirmation of the nickel allergy by a Dermatologist</li> <li>• Further episodes avoided using Nickel-free appliances or a plastic shield for the headgear facebow. (53-55).</li> </ul>
Latex allergy	Infrequent	<ul style="list-style-type: none"> <li>• Latex-free elastic components</li> </ul>

## Figure captions

1. Figure 1: Headcap / neckstrap for retraction headgear
2. Figure 2: Force-delivery module (snap-away) for retraction headgear (open and closed)
3. Figure 3: Locking facebow a) closed b) attached to clasp of upper removable appliance
4. Figure 4: Retraction headgear fitted to a fixed appliance
5. Figure 5: Retraction headgear fitted to a removable appliance
6. Figure 6 a) straight/combination pull, b) high-pull and c) low-pull retraction headgear
7. Figure 7: Facemask (Petit type)
8. Figure 8: Facemask (Delaire type) on a) dry skull with b) rapid maxillary expansion (RME)