Orthopaedic appliances

Introduction

Basically, there are two types of forces utilized in orthodontic practice:

1- **Orthodontic force:** It is a light force ranging from (50-100) grams. It can be applied using wires and other active components of removable and fixed orthodontic appliances. This force causes dentoalveolar changes without any skeletal changes.

2- **Orthopaedic force:** It is a heavy extraoral force ranging from (400-600) grams. This force causes skeletal changes. The appliances that produce orthopaedic forces are called orthopaedic appliances. Since these orthopaedic appliances employs heavy forces, an adequate anchorage is required. The latter is achieved by using extra oral means such as occipital, parietal, frontal cranial bones, and cervical vertebrae.

Philosophy of extraoral forces

A disproportion in the size or position of the jaws result in a skeletal discrepancy in either sagittal, vertical or transvers planes. To manage and treat these skeletal discrepancies, three different approaches are available;

i- Growth modification
ii- Dental camouflage
iii- Orthognathic surgery

Growth modification should be opted wherever applicable because this precludes the need for both tooth extraction and surgery. The goal of growth modification is to alter the unacceptable skeletal relationships by modifying the patient's remaining facial growth to favourably change the size or position of the jaws. Orthopaedic appliances are one of these appliances that are used to modify the growth of maxilla/ mandible.

Basis for orthopaedic appliances

Orthopaedic appliances generally use teeth as "handles" to transmit forces to the underlying skeletal structures. These appliances produce intermittent forces of very high magnitude. Such heavy forces when directed to the basal bone via teeth tend to alter the magnitude & direction of the jaws by modifying the pattern of bone apposition at periosteal sutures and growth sites. The followings are the basic principles of using orthopaedic appliances effectively:

a- **Amount of force**: The force magnitude should be high i.e, at least greater than 400 gm (400-600 gm) per side to make sure that only skeletal and no dental movement takes place.

b- **Duration of force:** According to most authors, intermittent forces produce skeletal change whereas continuous forces produce dental movement. Extraoral appliances should be worn for about 12-14 hours/day to bring about the desired effect.

c- **Direction of force:** The direction of force application should be such as to maximize the skeletal effect. A favourable skeletal effect is seen when a force is directed posteriorly and superiorly through the centre of resistance of the maxilla.

d- **Age of the patient**: Orthopaedic appliances are most effective during the mixed dentition period as it takes advantage of the prepubertal growth spurt.

e- **Timing of force application:** There is an evidence that there is an increase in the release of growth hormones more during the evening and night and is associated with the sleep onset. Therefore, it is advisable for the child to wear the headgear in the evening and throughout the night. Generally, the child is more likely to wear the appliance at night.

Types of orthopaedic appliances

The followings are the commonly used orthopaedic appliances:

a- **Headgear**
b- **Facemask**
c- **Chin cup**

Headgear

It is the most widely used extraoral orthopaedic appliances. It is ideally indicated in patients with excessive horizontal growth of the maxilla with or without vertical changes along with some protrusion of maxillary teeth, reasonably good mandibular dental and skeletal morphology. It is also used to distalize the maxillary dentitions along with the maxilla.

Components of headgear

1) **Force delivering unit:** such as face bow and j hook

a- **Face bow:** It is a metallic framework made of large gauge wire (Figure1.1). It can be attached to teeth either via brackets (fixed orthodontic appliances) or

removable appliances. This will help in delivering extraoral force to the posterior teeth.

Parts of face bow:

i- **Outer bow/ Whisker bow:** It is made of a round stainless-steel wire of 0.051" or 0.062" in dimension that is contoured around the face. The length of the outer bow can be adjusted to produce the desired force vector/ line of force. The outer bow on both sides at the distal end is curved to form a hook that gives attachment to the force generating unit. The outer bow can be classified into:

- Short: The outer bow is lesser in length than the inner bow.
- Medium: The outer bow length is equal to inner bow.
- Long: The outer bow is longer than the inner bow.

ii- **Inner bow:** It is made up of 0.045" or 0.052" round stainless-steel wire and it is adapted around the teeth to follow the dental arch shape to be inserted into the round buccal tube on the maxillary permanent first molars. U-loop stops, or friction stops are placed in the inner bow mesial to the buccal tube to prevent it from sliding too far distally through the tube.

iii- **Junction:** it is the point of attachment of the inner and outer bow, which may be soldered or welded. The junction is situated in the midline of the bows, although it may be shifted to one side in case of asymmetrical face.

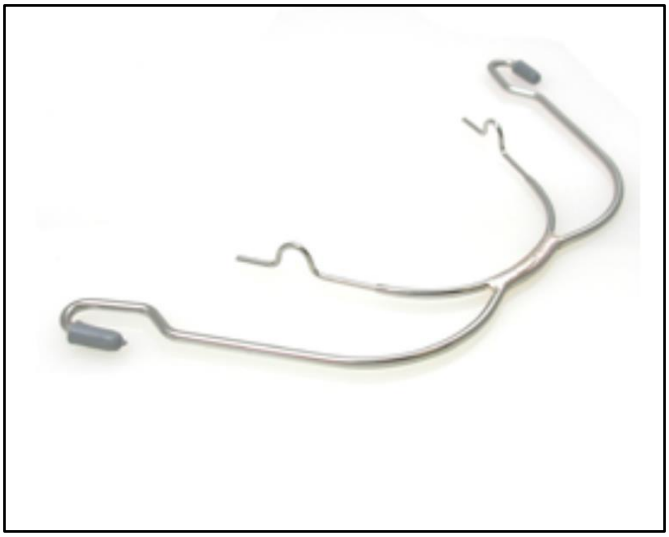

Figure 1.1: Face bow

b- **J hook:** This type of face bow consists of two 0.072" curved wires whose ends form hooks that are contoured to fit over a small soldered stop on anterior segment of the maxillary arch wire (Figure1.2). The normal site of its attachment on the arch wire is between the lateral incisors and the canine. Therefore, it is used along with

maxillary fixed appliance having a continuous arch wire to retract maxillary anterior teeth.

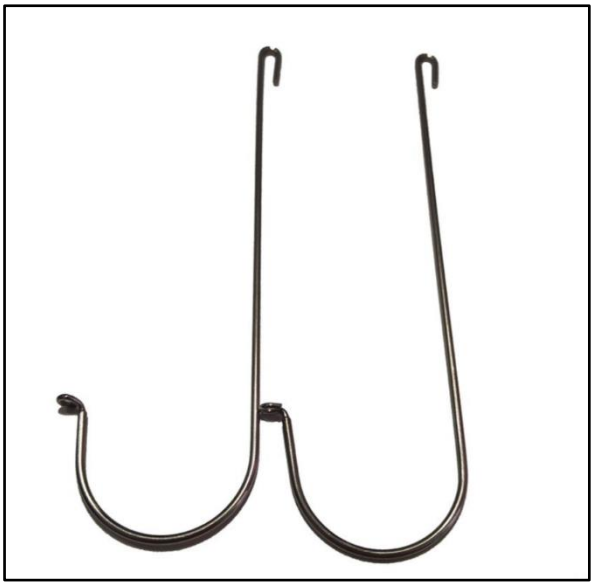

Figure 1.2: J hook

2) **Force generating unit:** It connects the face bow to the anchor unit (head cap or neck strap) and delivers forces to the teeth and underlying skeletal structures. This unit may compromise of either springs, elastics, or other stretchable materials. Springs are preferred as they provide a constant force whereas elastics tend to undergo force decay.

3) **Anchor unit:** The headgear appliance derives anchorage from extra oral anchorage sites such as, rigid bones of skull, back of the neck or a combination of them. Therefore, the anchor unit can be classified into:
   - **i-** Cervical attachment / neck strap.
   - **ii-** Occipital attachment / head cap.
   - **iii-** A combination of cervical and occipital attachments may also be used to distribute the external forces over a wide surface area.

Types of headgears

Based on the site of anchorage, headgears can be divided into:

1- **Cervical pull headgear:** This headgear obtains anchorage from the nape of the neck (Figure 1.3). it causes extrusion of the maxillary molars leading to an increase in the lower facial height. Therefore, this type of headgear is generally indicated in low mandibular angle and deep bite cases. In addition, it can also use to move the maxillary dentition and the maxilla in a distal direction for patients with Class II molar relationship.

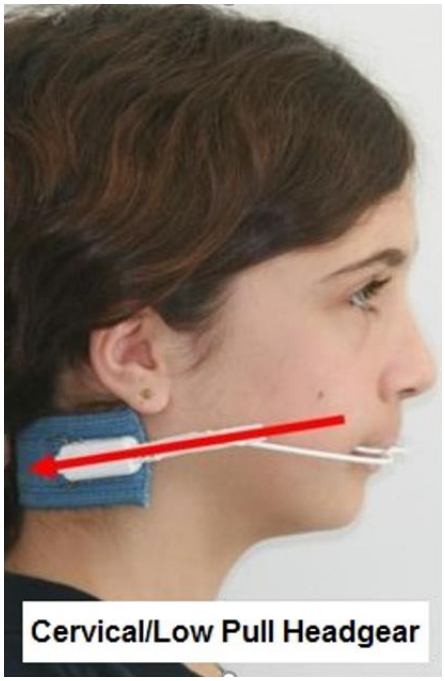

Figure 1.3: Cervical headgear

2- **Occipital pull headgear:** This type of headgear (Figure 1.4) derives anchorage from the back of the head (occipital region). It produces a distal directed force on the maxillary teeth and the maxilla. A slight superior directed force may also be seen.

Figure 1.4: Occipital headgear

3- **Combination headgear:** Both the occipital and cervical anchorage are combined in this type of headgear (Figure 1.5). When the forces exerted by both are equal, a distal and a slight superior directed force are exerted on the maxilla and maxillary dentition. Moreover, by varying the proportions of the total force derived from the head cap and the neck strap, the resultant force direction can be altered.

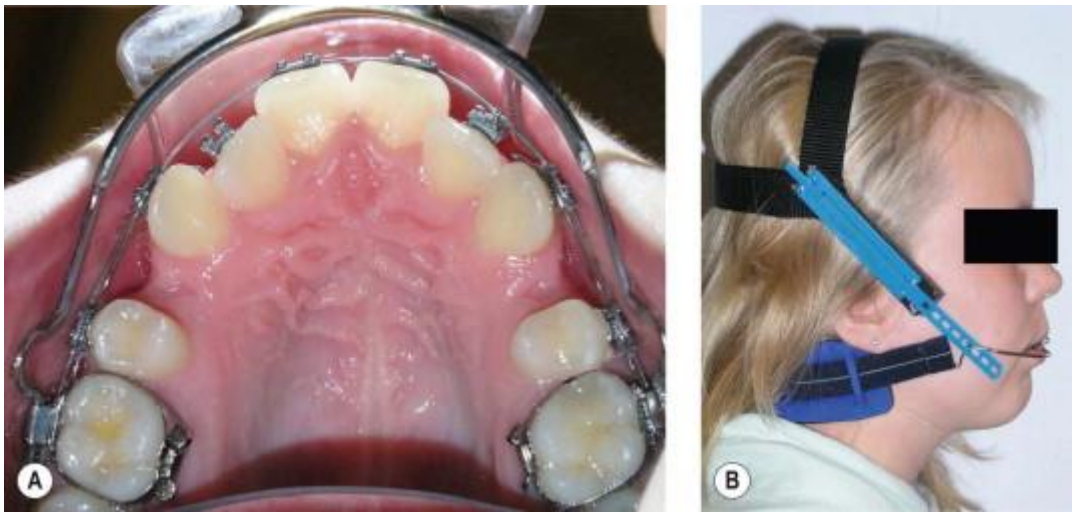

Figure 1.5: Combination headgear

4- **Vertical (high) pull headgear**: it derives anchorage from the front of the head (parietal region). Therefore, it produces a vertically directed force on maxilla and the maxillary dentition (Figure 1.6). As a result, it is used in individuals whom a decrease in the vertical development of maxilla is required such as long face class II patients and in patients with open bite tendencies. This headgear also exerts intrusive forces on the anterior region of the maxilla thereby producing a counter clockwise movement of maxilla. Therefore, it is useful in the treatment of vertical maxillary excess and gummy smiles. Intrusive forces on the posterior aspect of maxilla can be of benefit in anterior open bite patients as it intrudes the maxillary molars and therefore produces a clockwise movement of maxilla.

Figure 1.6: High pull headgear

5- **Asymmetrical Headgear:** This type of headgear is used when differential anchorage is required on both sides of the maxillary arch. For example: a patient with Class II molar relation on one side and a Class I molar relation on the other side can be given an asymmetric headgear. The different force values are produced by altering the length of the outer bow on each side and by variation of the angle between the outer and the inner bows.

Philosophy of headgear therapy

Headgear can move the dentition and the maxilla in all the three planes of space. Three factors should be considered when planning the use of headgears. These include:

a- **Centre of resistance of the dentition:** The inner bow of the face bow is generally attached to the maxillary first permanent molars through buccal tubes on these teeth. Thus, the force acting on the molars tends to displace them because the center of resistance is the point through which the resultant of forces acting upon a body would produce a translatory movement. A decision should be made whether bodily movement or tipping movement of the teeth is required. For example, the center of resistance of the permanent molar usually lies at furcation area (the mid-root region). When the applied force passes through the center of resistance, it causes bodily movement of the tooth. Alternatively, when the applied force directs below or above the center of resistance, it causes distal crown tipping or distal root tipping, respectively.

b- **Centre of resistance of maxilla**: It is believed that it exists at the posterio-superior aspect of zygomaticomaxillary suture (located between the roots of the two

premolars). Therefore, when force passes through the centre of resistance of maxilla, it produces translation of the maxilla in a distal direction. However, the forces passing above or below this point causes rotation of the maxilla.

c- **Point of origin of force:** Headgears derive anchorage from the occipital region of the cranium or the cervical region (back of the neck). Occipital headgears produce a superior and a distal force on the teeth and the maxilla, while cervical headgears produces an inferior and a distal force. Thus, an appropriate point of origin or site of anchorage should be selected based on what type of tooth and maxillary movement would be beneficial for a given patient.

d- **Point of attachment of force:** It refers to the hook present on the distal end of the outer bow to which the force generating unit is attached. It is possible to alter the direction of force to the maxilla and the dentition by altering the point of attachment. This can be done by varying the length of the outer bow or by varying the angle between the inner and outer bows.

Facemask

It is also called “protraction headgear” or “reverse pull head gear” or Delaire facemask. It is used to treat class III malocclusions that results from a combination of maxillary deficiency and mandibular excess in growing patients (around 8 years). This means it aids in pulling the maxillary structures forward and pushing the mandibular structures backward. It also be used for selective rearrangement of the palatal shelves in cleft patients.

Components of Facemask

Basically, facemask consists of the following:

1- **A rigid metal extraoral framework:** It is the main component of a facemask assembly. It connects the various components such as the chin cup and the fore head cap. It also has provision to receive elastics from the intraoral appliance. The design of the metal frame differs based on the type of facemask.
2- **Chin cup or pad:** It takes anchorage from the chin area. It is usually connected to the rest of the facemask assembly by means of metal rods.
3- **Forehead support or cap or strap:** It is used to derive anchorage from the forehead area.
4- **Heavy elastics:** These elastics are used to apply a forward traction on the upper arch. The vertical posts of chin cup are used to attach the elastics onto the upper molars or hooks soldered on the upper arch wire.

5- **Intraoral appliance;** it is the most common type of protraction device is a multi-banded appliance with a ridge wire. Traction hooks are placed either in the molar or premolar region. McNamara advocates a banded rapid maxillary expansion along with the protraction device (Figure 1.7) that resembles the banded Herbst appliance.

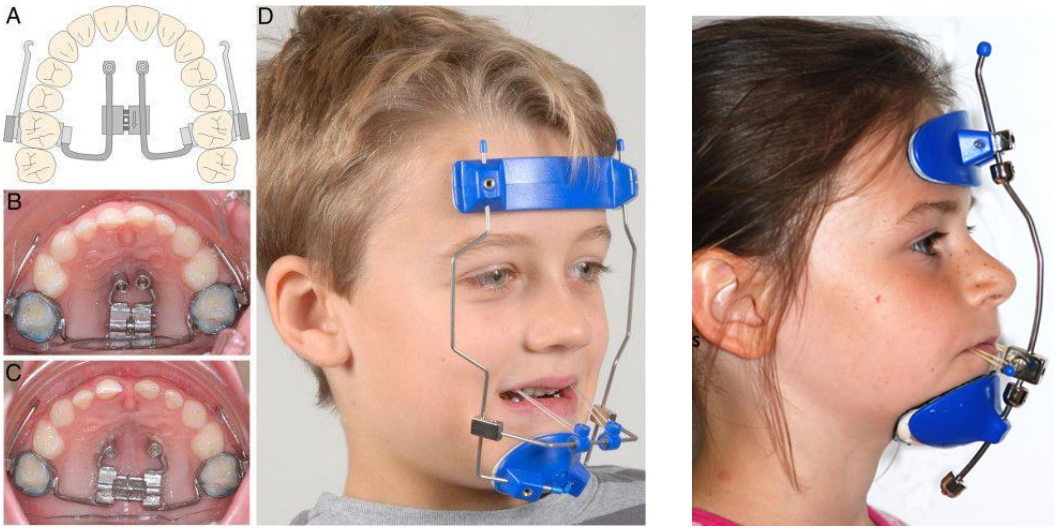

Figure 1.7: Facemask

Basis of using facemask

a- **Amount of force:** The amount of force required to bring about skeletal changes is about 1 pound (or 450gms) per side.

b- **Direction of force:** Most authors recommend (15-20) degrees downward pull to the occlusal plane to produce a pure forward translatory motion of the maxilla. If the line of force is parallel to the Occlusal plane, a forward translation as well as an upward rotation take place.

c- **Duration of force:** The time taken to achieve a desired result is proportional to the amount of force utilized. For example, Low forces (250 grams /side) take 13 months to produce desired results. However, very high Force values like 1600-3000 grams reduced treatment time to 4 -21 days.

d- **Frequency of use:** Most authors recommend 12-14 hours of wear a day.

Philosophy of facemask therapy

The principle of using this device is by applying a pulling force on the maxillary suture with reciprocation pushing force on the forehead and/or chin through facial

anchorage. A forward maxillary pull is applied with the help of heavy elastics that are attached to hooks on the rigid framework.

Chin cup

It is an extraoral orthopaedic device that covers the chin and is connected to a headgear. It is used to retard or redirect the growth of mandible. Therefore, it is indicated to treat class III malocclusion due to a protrusive mandible but a relatively normal maxilla.

Components of chin cup

Chin cup consists of the following:

1- **force module**: ex. Elastics/metal springs that provide the desired tension levels on the chin cup.
2- **chin cup**
3- **head cup**

Types of Chin cup

Generally, chin cups are of two types:

1- **Occipital -pull chin cup:** This is the most commonly used type of chin cup (Figure 1.8) that derives anchorage from the occipital region of the head It can be used to treat the following:

- Class III malocclusions associated with mild to moderate mandibular prognathism in patients who can bring their close to an edge to edge at centric relation.
- Patients with slightly protrusive lower incisors as it produces lingual tipping of lower incisors.
- Patients who begin treatment with a short lower anterior facial height as this appliance can lead to an increase in this dimension.

- 

Figure 1.8: Occipital chin cup

2- **Vertical-pull chin cup:** This derives anchorage from the parietal region of the head (Figure 1.9). It is indicated patients with high mandibular plane angle and excessive lower anterior facial height as it helps to close the angle of mandible and increase posterior facial height. These patients usually exhibit anterior open bite.

Figure 1.9: Vertical chin cup

Fabrication of the chin cup

Chin cups are either:

- **fabricated** individually for the patient (custom-made chin cup). It requires an impression to be taken of the chin area. The cast is poured, and the chin cup is fabricated using self- cure acrylic resin.
- **prefabricated (**commercially-available chin cup).

Philosophy of Chin cup therapy

Mandible grows by apposition of bone at the condyle and along its free posterior border. Condyle is not a growth centre and condylar growth is largely a response to translation of surrounding tissues. This contemporary view offers a more optimistic view of the possibilities for growth restraint of the mandible, as with chin cup therapy considering the following:

1- Direction of Force:

The direction of force is determined by the position of the head cup. Therefore, it can be divided into:

a- A line of force directed below the condyle, it resulted in:
- A downward and backward rotation of the mandible.
- Less force is required.
- An increase in facial height due to a decrease in the prominence of the chin.

b- A line of force directed through the condyle with the intent of impeding mandibular growth. This method causes no opening of the mandibular plane angle.

c- A line of force directed vertically on the chin which lead to
- Decrease in mandibular plane angle.
- Decrease in the gonial angle.
- Increase in posterior facial height.

2- Magnitude of Force:

Most of the reported studies recommended an orthopaedic force of 300-600 gm per side. However, at the time of appliance delivery, a lower force level (about 150 gm) may be advised for the patient to get used to the appliance. Thereafter, the force is gradually increased to the recommended level over the next two months.

3- Duration of Wear

A maximum of 12-14 hr/day of chin cup wear is recommended to achieve the desired results.

Effects of Chin cup therapy

Although most human studies have failed to conclusively prove that chin cup inhabits mandibular growth. the following effects are seen:

4- Redirection of mandibular growth in a downward and backward direction.
5- Remodelling of the mandible and a decrease in mandibular plane angle and gonial angle.
6- Lingual tipping of lower incisors.
7- Improvement in skeletal and soft tissue profile. Therefore, chin cup works well in patients with reduced or normal lower anterior facial height but is contradicted in long face patients.