Class II Treatment Modalities and Airway Evaluation

Christopher C. Cosse
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Introduction

One of the most heavily debated areas in orthodontics has been and still is the best method of class II correction. Many modalities have been developed in an effort to find the ideal class II corrector. As early as Edward Angle, the possibility of stimulating growth and of achieving considerable changes in the maxillary and mandibular morphology has been considered. Angle believed that if a normal function were established, adaptation of the craniofacial pattern would subsequently follow.[1] The introduction of cephalometric roentgenology proved that this theory was incorrect.[2] At any given time in history there has been an idea that is assumed true, when that idea is critically evaluated, it often creates a paradigm shift that alters the way we see the future. What Angle believed in 1907 is much different from what we believe today. This is because research and technology have advanced at a staggering rate. It is logical, therefore, to assume that many of the ideas we "know" to be true may in fact be incorrect when critically evaluated. Many of the modalities that we use today are not soundly based in research and are theories, at best. Many practitioners are using class II correction modalities because that is what they were taught or " it works in my hands".

Another area of much controversy is the evaluation of airway and what role airway plays in orthodontics. Many believe that airway disturbances cause a myriad of developmental deformities such as "long face syndrome", steep mandibular plane angles, prognathisms, asymmetries, anterior and posterior openbites and some TMJ problems.[3] Yet many practitioners ignore the signs and symptoms of airway disturbances either due to lack of formal training in this area or due to questions concerning the role airway interference plays in the etiology of such deformities.

Class II Correction Modalities

The Herbst appliance, developed in the early 1900's and reintroduced in the 1970's by Pancherz, can either be a fixed or removable appliance. It can be cemented to the teeth or clasp retained, depending on compliance. This device resembles the shocks on a car or a hydraulic system. It is nothing more than a pin and tube apparatus that positions the mandible forward.[4] It is based on the same philosophy as the twin block and Jasper jumper. It is actually banded to the upper molars and to the lower canines in one type of Herbst appliance. According to Pancherz, in this type you actually get some distalization of the upper molars at the same time that you are protruding the mandible.[5] The Herbst appliance exerts an orthopedic effect by positioning the mandible forward in an ideal position or even further forward. Stockli and Wilbert first reported in 1971 that the overall forward positioning of the mandible could be in part due to anterior remodeling of the glenoid fossa.[16] Woodside confirmed that the continuous and progressive mandibular protrusion produces extensive anterior remodeling of the glenoid fossa.[18] The effects on the maxilla is similar to high-pull headgear, according to Pancherz, providing maxillary distalization. The Herbst may be valuable in maxillary crowded cases and open-bites due to the intrusion mechanics.[14] The Herbst appliance is probably the hottest topic on the circuit today. Just pick up a journal and you will find this appliance being discussed. Part of its popularity stems from the fact that it works well with non-compliant patients and with "supposedly" non-growing patients.[6] These are reported to be two of the main advantages of the Herbst appliance. It also works best on Class II division 2 malocclusions, because proclination of the lower incisors during treatment (anchorage loss) is advantageous in this

type of occlusion.[7] The Herbst appliance can be used as a splint therapy in patients with some types of TMD, although TMD is often multifactorial and one should not use this alone to treat TMD. Studies by Hansen[8], Paulsen[9], and Ruf[10]all determined that the Herbst does not seem to have an adverse long-term effect on the TMJ.

In a study of the morphological changes of the TMJ condyles of 100 patients treated with the Herbst appliance in the period of puberty to adulthood, a long term radiographic study found that the orthopedic effect was, in most cases, visible as a change in the morphology of the condyle, as a double contour in the distocranial part of the condyle and sometimes also at the distal surface of the ramus. In two cases, remodeling resorption was found in the anterior part of the condyle after Herbst treatment, again a sign of adaptation to changed mechanical influence. In most cases, stable remodeling occurred whether the patient was pubertal, late pubertal or adult.[8] In another study by Ruf and Pancherz, Class II subjects treated to a Class I occlusal relationship with the Herbst appliance were analyzed. Radiographs were taken before and after an average treatment period of 7 months. Treatment was found to be achieved by greater dental than skeletal changes.[11] Treatment with the Herbst appliance was studied via CT and radiographs on a patient chosen to represent the total effects of this appliance. This study showed that treatment resulted in marked dentoalveolar changes, an increase of mandibular length, ramus height, and gonion angle. Three months after insertion of the Herbst appliance new bone formation as a double contour in the fossa articularis and on the posterior part of the condylar process was a result of adaptive bone remodeling.[12] Konik, Pancherz, and Hansen concluded from their study that the Herbst appliance was equally effective in pre- and post pubertal patients.[6] These results have been abused by orthodontists and misconstrued to mean that the Herbst appliance is an effective skeletal class II corrector for adults. This has cleary has not been proven. The mean late stages Konik, et al. used MP3-H,and -I translated, in the original study, to be approximately 13.45

to 14.32 in girls and 15.5 to 16.29 in boys.[13] To assume from this, that the Herbst works this way in adults is bold to say the least. Since the Herbst appliance utilizes that growth potential of the condyles, therapy is not recommended for non-growers to avoid developing a dual-bite or TMD. Pancherz thus advocated an early treatment approach.[19] Together with other investigators in his group such as Hagg[20], Hansen[21] and Konik[6], they determined that the optimal timing is at or just after peak height velocity of the patient's growth. Differences between the late and early treated patients were only found for the dental changes: the upper incisors were retroclined and the mandibular incisors were proclined more in the late cases.

Relapse is an ever-present problem with Herbst therapy. Skeletal and dental relapse are common with the majority of dental relapse occurring within the first 6 months post-treatment. Pancherz found that 58% of the subjects occlusal relapse was exclusively a result of tooth movements while unfavorable maxillary and mandibular skeletal jaw growth contributed to relapse in 42% of the subjects.[22]During treatment it was found that maxillary growth was inhibited and redirected while the mandibular growth was increased. After treatment, the maxillary and mandibular growth seemed to strive to catch-up with their earlier pre-treatment patterns. It seems as if the inherent morphogenetic pattern dominates over treatment procedure.[23] Weislander found that even though the overall treatment effects still existed in a group eight years post-treatment, they had decreased to a non-significant amount when compared to controls. An average of 1.5 mm net mandibular advancement remained out of the original 3.9mm gained during treatment. Results were better the longer the patient stayed in retention.[24]In summary, the Herbst, undeniably ,is a viable option in the treatment of class II malocclusions in growing patients. The percentage of skeletal to dental was reported by Pancherz to be about 50%/50%.[15] In 1997, Konik observed 32% skeletal and 68% dental;[16] And Wong et al. found 35% skeletal and 65% dental.[17] It is, however, doubtful that this appliance even gets this much skeletal movement in a non-growing patient. In addition, Pancherz et al.

Found that the Herbst only has a temporary impact on the existing skeletofacial growth pattern. After the orthopedic interventive treatment period, maxillary and mandibular growth seemed to strive to catch up with their early patterns.[76]

Another common method of Class II correction involves extraoral anchorage. Extraoral anchorage was defined in 1919 in the book Practical Orthodontia by Dewey and Martin as "that form of anchorage in which resistance necessary to overcome the malposed tooth or teeth is derived from some source outside the oral cavity. Headgear fits into this category. It offers the most immovable base that can be obtained. The reciprocal force, unlike intraoral anchorage is not directed against teeth, but against the cervical, occipital, frontal, or mandibular regions to avoid unwanted tooth movement."[25]

Cellier first recorded the use of cranial anchorage for orthopedics in 1802 when he used chin caps to corrrect an "underslung chin". Extraoral anchorage was gaining popularity to correct orthopedic problems such as prognathia but it was first used with intraoral attachments in 1866 by Kingsley.[26]Headgear appliances that made use of extraoral force were first introduced in the late 1800's.

They were first described and used by the pioneer orthodontists of the time, the most prominent being Angle and Kingsley. Proffit, when looking back on these early appliances described them as "astonishingly modern-looking and apparently capable of reasonable success."[4]By the early 1900's, these early proponents of extraoral anchorage had changed their tune and were now singing the song of intermaxillary elastics. They even predicted that extraoral anchorage was a thing of the past and would not be used in the future.

Dewey, in 1935, wrote "extraoral force is now seldom used, the chin cap, head cap, and cervical and occipital anchorage in forms utilized in the past, are now displaced by simpler and less

conspicuous sources of resistance to force. Better patient compliance and ease of use would make intermaxillary elastics the treatment of choice for class II and class III cases.[25] Case was one of the few who remained steadfast in his belief in extraoral anchorage and later introduced the cervical and combination types of headgear.

In the 1940's cephalometrics presented a new opportunity to view treatment outcomes. Oppenheim found, intermaxillary elastics, while providing dental movement, were not producing the improved skeletal effects they were believed to be causing. He wrote that headgear would be valuable to treatment and that it would produce better orthopedic results if it were worn intermittently rather than continuously.[27] Practitioners once again began subscribing to the benefits of extraoral anchorage. Kloehn had many successful cases at close to the same time which helped promote this paradigm shift. He was the first to describe the "guiding of growth of the alveolar process and the eruption of the teeth" and the concept of restricting growth of the maxilla while the mandible was allowed to follow its normal pattern of growth.[28]

Kloehn is credited with the design of the currently used double facebow for application of extraoral force to the maxillary molars.[29] Research is still being done on the uses of extraoral anchorage and the amount and direction of forces to be applied.

According to Proffit, the probable minimum force required to resist forward movement of the maxilla is in the range of 250 grams per side of the arch. His force prescription which lists the optimum conditions for headgear to restrain maxillary growth is:

1) A force of 500 to 1000 grams total
2) The direction of force to be slightly above the occlusal plane (through the center of resistance of the upper molars if force application is to the molars by facebow)
3) A force duration of 12 to 14 hours per day (8 hours minimum for significant effects)

4) A treatment time of 12 to 18 months depending on growth and patientcompliance.[4]

Weislander found that when he splinted the maxillary arch together he could apply an orthopedic force of 1500 grams per side without discomfort to the patient.[30]

Weislander's philosophy on timing of initial treatment with extraoral traction is to make the overall treatment coincide with the pubertal growth spurt of the patient. He also found best results of the skeleton and dentoalveolous when the patient was in the early mixed dentition. (average age was 8 to 9 years).[31] West and Weiss found similar results.[32,51] Armstrong found dramatic orthopedic results when he treated patients in the late mixed dentition, but he also advocated 24 hour headgear wear.[33] Moyers found two growth spurts, one at around age 9 and one at around age 12 for girls and 14.5 for boys.[4] Sakamoto's results in 1981 agreed with these findings. He found that he missed the initial growth spurt in most of the patients that he started between the ages of 9 and 12 years of age. His chin cup therapy caught the growth in most of the 3 to 8 year old patients.[34] In 1982, Fishman found that there was a discrepancy between chronological age and skeletal age. The skeletal maturity index, which he uses today, is very accurate and predicts growth based on a hand-wrist analysis. Peak growth is between SMI 4 and SMI 7, with SMI 8 being too late to alter growth significantly.[35]

Although there are many types of extraoral appliances, they are classified according to the point of origin of the force, which in turn determines the direction of the line of action of the force produced. Extraoral orthodontic appliances generally comprise an inner and an outer bow soldered together near their respective centers. When eccentric forces are desired, the inner and outer bows of the headgear appliances are attached to each other asymmetrically. Extraoral force is delivered by means of springs, elastics, or stretchable material, attached to a neck or headgear assembly

usually constructed of a pliable material. Generally, the inner bow engages tubes attached to the buccal portion of bands attached to the molar teeth. The key to understanding the effects of extraoral forces on a molar tooth is an appreciation of the relationship of the line of action of a force to the center of resistance of a tooth.[36]

Cervical is the most widely used appliance for extraoral anchorage. It consists of the typical facebow attached to a strap that passes around the nape of the neck. Cervical appliances can be used effectively in certain cases,but if used incorrectly or more accurately, applied tothewrong type of case, the results can be detrimental. [37]

A combination of effects that are often seen with the use of cervical facebow have been referred to as the "Kloehn reaction". Most of these effects are undesirable for treatment of most class II cases. Some of these effects include downward tipping of the palatal plane, the occlusal plane, and the mandibular plane, general extrusion of the maxillary denture including the incisors, but predominantly the upper molars. All of these together produce a general downward and backward rotation of the lower face. This effect will be more severe in hyperdivergent facial types with steeper mandibular plane angles.[38]

In a 1960 study using cervical pull headgear Ricketts found that it definetly had a restraining effect on the maxilla. More downward growth was seen but less forward growth. This caused the mandibular plane to rotate downward and backward causing it to become steeper.[39]

Schudy in 1965 found similar results and concluded that cervical headgear is contraindicated in a patient with a vertical type growth pattern.[40]Merrifield determined from over 200 headfilm tracings with cervical headgear in place that the direction of force was at an average angle of 30 degrees below the occlusal plane. When broken

into vectors, this direction has a distal component and an extrusive component on the upper molar. He sums up the undesirable actions of the cervical facebow as: It enhances downward movement of the maxilla and maxillary teeth, it moves the maxillary teeth distally, and it causes mandibular rotation. Molar extrusion is undesirable because it results in counterclockwise mandibular rotation which causes pogonion to move in a downward and backward direction, worsening the class II profile. These results can be good if the patient has a severely deep bite in a class II malocclusion.[41]

A line of force acting in the occipital direction is probably the most ideally directed force because this direction is probably the most closely parallel to the occlusal plane thereby minimizing extrusive forces. It is difficult to design a strap to pull straight back because of the shape of the head and the placement of the ears. A combination headgear is usually the way the desired effect is achieved. Two straps are used. One is a cervical pull and the other is a high pull or parietal pull strap.

Comparing occipital pull headgear to cervical pull headgear, more distal movement and less extrusion are achieved with occipital forces as a direct result of the force vectors involved.

Badell in 1976 studied the effects of an occipital pull headgear. He used 24 to 36 oz elastics in a parietal direction and a 16 oz elastic in a cervical direction. This was done for 14 hours per day for three weeks and then only at bedtime for an additional nine weeks. He found slight rotation of the mandible and very little effect on the maxilla. This was probably due to the short duration in which the combination appliance was actually worn. The effects did show that the results of the high pull headgear would be useful on those with a vertical type growth pattern.[42]

Parietal or high pull headgear is one that can be adjusted using the strap assembly to alter the direction of the force. The line of action is in a posterior and upward direction.

This is one of the most widely used appliances for extraoral anchorage today. This is because of the fact that the line of action produces results that are consistent with the treatment of class II malocclusions. Poulton states that the cases that are treated successfully with this appliance alone are in the minority.[43]

Baumrind, in 1978, found in his study of over 300 class II patients that among the various types of headgear, high pull headgear resulted in the greatest orthopedic and dentoalveolar effect. It also had the tendency to impact the posterior maxilla. This can be of considerable value when trying to treat an anterior open bite case or someone with a long lower facial height.[44]

Intrusion of the posterior maxilla can also have the effect of rotating the mandible closed or upward and forward causing a class II patient to appear more class I. This will decrease the steepness of the mandibular plane.

In 1992 Firoux used high pull headgear to show that the effects on the maxillary molars was more displacement rather than tipping. Also, the maxillae showed less downward and forward growth, with the palatal and mandibular planes showing no significant change.[45]

J-hook headgear is usually attached to the archwire but can be attached to canines or any other individual teeth. It is used to distalize teeth when there exist maximum anchorage concerns in the posterior region. This type of headgear can have an intrusive effect and is often used in cases of deep bite or where a gummy smile exists or it can have an extrusive effect depending on the force vectors. The j-hook is one of the few types of headgear that can be attached to the lower arch.

Klontz describes the effectiveness of this type of headgear when used in the Tweed-Merrifield directional force systems. Tweed and Merrifield have done extensive research of the J-hook and have

found a way to direct the j-hook through the center of resistance and thus decrease the tipping associated with other types of headgear.[46]

Chin cups have been around since the mid 1900's but the results have been less than reliable. Graber[47], Wendell[48], Thilander[49] and Sugawara[50] have found varied results. These studies found that the use of the chin cup can result in changes in the condylar neck, such as thickening and shortening, as well as increases in the interpolar and anteroposterior width of the condyle. Treatment times in most of these cases averaged 3 years with a range of 1 to 6 years. The ideal patient according to Proffit, would have a mild class III skeletal problem with the ability to bring the incisors end to end, a short vertical face height and normally positioned or protrusive lower incisors. The chin cup has a lingual force on the lower incisors. Proffit uses the chin cup in two ways. One, application of force should be in a line with the mandibular condyle, with the intent of impeding growth. This has been shown to work in animals but has not been successful in humans. Two, direct the force below the mandibular condyle so the mandible is rotated down and back. This results in increased face height but works better than the first method.[4]

Reverse pull or protraction headgear was developed utilizing anchorage from the facial bones. Later Nelson designed an appliance which created anterior traction to the maxilla from a facemask attached to a helmet. The traditional type of reverse headgear, like we use today was developed by Delaire in the late 1970's. He placed rests against the forehead and the chin and he found that he got an orthopedic correction if he began treatment prior to the age of eight. After eight years of age most of the change was dentoalveolar. Protraction may be more successful if the palate is widened before the headgear is used.[52]

Ngan in 1997 reported that his skeletal class III patients that were treated with Rapid palatal expansion and a facemask obtained

a positive overjet in just 6 to 9 months of treatment. He found that the changes were due to the maxilla moving forward and the mandible rotating downward and backward. Proclination of the maxillary incisors and retroclination of the mandibular incisors also contributed to the positive overjet. [53]

In 1997 Williams found that rapid palatal expansion in conjunction with protraction had very little orthopedic effect and moderate dentoalveolar effect which created the correction. These results could have come about because of the age of the patients (8.3years average).[54]

But, Merwin in another study found that the age was not significant, between the ages of 5 and 12years. The results he found were very similar in his 5 to 8 group to his 8 to 12 group.[55]

In 1998 Gallagher found the combination showed an increase in maxillary protraction of 1.6mm per year more than normal. He also found some relapse over time.[56]

Headgear is almost always used in conjunction with other fixed appliances as an aid to achieve specific treatment goals. The majority of cases that incorporate the use of headgear are of the class II variety. Simply put, it is used to move the maxillary teeth distally and to hold the maxilla and keep it from growing forward in the class II relationship.

Patients with long face syndrome or excessive height can be treated with headgear. The optimum treatment would be to restrict any vertical growth of the maxilla with the use of a high pull headgear.

Patients that have a short face or vertical deficiency often have an accompanying anterior deep bite, a class II Div. 2 malocclusion, and some degree of mandibular deficiency. It would be beneficial to use a cervical headgear in this case, with an extrusive component to

open the bite and cause a forward rotation of the mandible.

An anterior open bite that is the result of excessive posterior eruption can be treated with high pull headgear to the maxillary molars. It is a difficult treatment that is usually done in the finishing stages of treatment and maintained until growth is complete.

Extraoral force to the posterior maxillary segments can be used to increase the anchorage when using class III elastics, or when sequentially retracting maxillary canines and incisors.

Headgear has undoubtedly withstood the test of time,with research backing it up, and has proven itself to be worthy of anyone's "orthodontic tool box". Weislander and Buck concluded that headgear is relatively stable 6 years out of retention.[77] On the other hand, Melsen found that after headgear treatment was discontinued, the direction of growth changed considerably. She found that the maxillary complex will catch up later with the amount of growth that could normally be expected.[78]

The jasper jumper is another appliance that is designed to achieve a correct anterior/posterior relationship by, in essence, "jumping the bite". Class II division I malocclusions are a very frequent problem in the orthodontic practice, Droschl reported the frequency to be 37% among school children.[57] In another study by McNamara where 277 children with class II malocclusions were studied, the majority of them were characterized by mandibular retrusion.[58]Studies have been performed on the compliance of patients and they have proven that patients satisfy about one half of the wearing time requirements suggested by the orthodontist.[59] In the 1980's J.J. Jasper tried to create an appliance in an attempt to combine the benefits of having a fixed appliance while incorporating pushing forces on the dentition.

Both the Jasper Jumper and the Herbst appliance use pushing intraoral forces versus pulling intraoral forces as is used

with elastics alone. The Jasper Jumper is much more flexible than the Herbst and is used in the treatment of intermaxillary Class II malocclusions.[69] The jasper jumper could be used in the treatment of intermaxillary class III malocclusions by placing it on the lower first molars and upper canines, but this is not used as often.[61] This device is a thick, rubber coated wire that, when bent becomes activated and wants to return to its natural straightened position. The jumper mechanism, which is available in a number of different preselected sizes, is attached to the maxillary facebow tube, attached to the first molars, through the use of a soft wire with a ball on one end. The ball pin wire can be bent into a hook to secure it. The jumper mechanism fits over the lower arch wire and a lateral bayonet bend is placed distal to the lower canines. It is recommended that premolar brackets are removed prior to insertion in order to obtain 6-8mm of space distal to the lower arch ball stops. A small acrylic ball is placed adjacent to the bayonet bend, and the arch wire is placed through the anterior hole on the Jasper Jumper. On the maxillary arch, the action of the Jasper Jumper is to support and expand the molars, therefore a rectangular arch wire with palatal crown torque is recommended. If an upper palatal arch is used to control this movement, any size of wire would suffice.[69] On the mandibular arch, there is a tendency of this device to cause proclination of the incisors, consequently lingual crown torque would be placed on the incisor area to minimize this movement. Usually 6-9 months of Jasper Jumper wear is necessary in order to correct a mild Class II problem in patients who still have some growth remaining.

There are basically two different interarch force vectors that may be used to effect intermaxillary malocclusions. First are pulling forces as are produced using elastics. These pulling vectors not only produce sagittal forces, but also produce extrusive forces which may produce undesirable effects. Extrusion of upper incisors and lower premolar extrusion can open the bite and may negatively effect the profile and occlusions. Extrusive forces may be indicated in patients that need an increase in lower facial height. With this in

mind, McNamara has shown that only about 10% of patients with Class II mixed dentitions have decreased lower facial height, with 30-50% having excessive vertical development.[58]The pushing forces of the Jasper Jumper would be ideal in these cases. Pushing forces are produced mainly by two appliances, the Herbst appliance and the Jasper Jumper. Pushing forces not only have sagittal forces, but also have intrusive forces [63,64,65] which have proven to be beneficial in many cases when treating a class II malocclusion. Pushing forces usually parallel the natural growth vector of the face as was shown by Weiland and Bantleon[66]

The Jasper Jumper is a fairly new appliance relative to the Herbst appliance, and is sometimes considered a flexible modification of the Herbst. There is very little scientific research evaluating the Jasper Jumper, and much of the premise behind this appliance was modeled by the Herbst appliance. There are some advantages of the Jasper Jumper over the Herbst such as an improved amount of controlled force that can be applied to the dentition. This flexibility in the force module increases patient comfort and curves away from the dentition in its activated position, making mastication and oral hygiene procedures easier to perform than with the Herbst. Another advantage is that the Jasper Jumper may be added to other existing appliances after the arches have been stabilized and prepared for the appliance.

The stresses and movement of the lower dentition may be minimized by placing stabilization wires such as a lower lingual holding arch. In a study by Weiland [67] the Jasper Jumper, when compared with the activator and activator/headgear combination, produced the most rapid and significant distalization of maxillary molars and mesial movement of mandibular molars. If this movement of the molars exceeds the movement of the anterior teeth you may get a loss of leeway space. Other disadvantages of this appliance are breakage, due to patients chewing on it, or unwanted tooth movement. Since the movement of the dentition is so rapid with this appliance, and as will be stated later, most of the movement is

dentoalveolar, there are some considerations that need to be addressed with regard to root resorption.

An area of confusion regarding this appliance has been with regard to the means by which it causes craniofacial changes. It has been hypothesized that orthopedic effects could be achieved, but evidence is lacking. Others believe that the majority of the movement is dentoalveolar. In a study by Cope et al. 31 subjects were treated for class II malocclusions by Jasper Jumper therapy. Most of the class II correction was accomplished by dento-alveolar movement and secondarily by maxillary basal restraint. In this study, there were no significant results quantifying condylar growth, fossa remodeling, or forward mandibular development.[68] These results were substantiated in a study by Mills and McCulloch, cephalometric analysis revealed that despite seemingly adequate anchorage for springs, treatment changes were largely dentoalveolar, with minimal improvement in the underlying skeletal structures. Some restraint of maxillary growth was found, but most of the overjet correction was due to forward movement of the mandibular dentoalveolar complex and retraction of the maxillary dentoalveolar complex.[71] In both of these studies some other similar results were found: there was a backward displacement of the maxilla, and unfavorable clockwise rotation of the mandible. Even though one of the major claimed advantages of the Jasper Jumper is intrusion of the teeth, both of these studies found that there was significant extrusion of the mandibular molars in addition to intrusion of the mandibular incisors and maxillary molars.

Jasper's [70] "theory of two's" claims that the Class II correction can be divided equally among five component parts: Maxillary basal restraint, backward maxillary orthodontic movement, forward mandibular orthodontic movement, condylar growth and downward/forward glenoid fossa remodelling. There seems to be no disputing among almost all of the research that some of the movement is dentoalveolar. There are some studies however, that find substantially higher amounts of skeletal movement and

development during Jasper Jumper therapy. In a previously mentioned study by Weiland and Bantleon [66], 17 growing patients were treated for Class II malocclusion with the Jasper Jumper. The correction was are result of 40% skeletal and 60% dentoalveolar changes. The majority of the skeletal changes were mainly restricted to the mandible. In yet another study by Weiland FJ et al. 25 patients used the Jasper Jumper to correct a class II malocclusion. Correction of the distal occlusion occurred through a combination of skeletal and dentoalveolar adaptations. Skeletal changes accounted for 48% of the overjet correction. Dentoalveolar compensation appeared to be inversely related to skeletal adaptation.[67] Relapse tends to be a problem and most of the skeletal movement is converted to dento-alveolar movement as skeletal relapse occurs while the teeth are retained.[67]

The key is believed to be growth potential. This appliance seems to need growth to get skeletal changes to occur, if any occur at all. More studies need to be done in order to fully understand the mechanisms by which this appliance works. In summary, this appliance works essentially by dento-alveolar correction.

Functional Appliances started gaining popularity in the United States in the early 20th century, Victor Hugo Jackson was the chief proponent of removable appliances. But, the materials of that time were often hard to work with and cumbersome to the patient.

George Crozat, in the early 1900's, developed a following out of New Orleans that was very interested in his new "Crozat Appliance". His appliance was removable and more flexible than earlier models, and was fabricated completely of precious metals. Although this appliance is still used today, it did nothing to change mainstream orthodontics, which was grounded in a firm belief in fixed appliance therapy.

In Europe, on the other hand, Fixed therapy had not increased in popularity and removable appliances were even more

readily being used. Proffit states, in his book Contemporary Orthodontics 3 major reasons for this trend.

1) Angle's approach to occlusion han not caught on in Europe.
2) General practitioners were doing the majority of the Orthodontics in Europe due to social welfare and the fact that it was easy to use.
3) Precious metals were less available in Europe, both as a consequence of the social system and because the use of precious metals in dentistry was banned in Nazi Germany and orthodontists there were forced to emphasize removable appliances. [9]

Even today Orthodontists in the United States mainly emphasize fixed therapy while their European counterparts go towards a removable approach. Recently though, orthodontics in each part of the world is starting to overlap.

Half of the patients treated in the U.S. are Class II malocclusion. All too often the maxilla is treated when the problem lies with a mandible which is underdeveloped, possibly retropositioned, or both.[4] Orthodontists today are opening their eyes and minds to functional appliances, not as a cure-all treatment, but as an adjunct to their current armamentarium. Journals, newsletters, and company representatives are currently bombarding today's orthodontist with "the latest and greatest functional appliance". Most are variations of either the Frankel appliance, the twin block, the activator/bionator, the Herbst, or the Jasper Jumper. Once a working knowledge of these appliances has been obtained, one will be able to evaluate most appliances that will be presented to one in the future. The Herbst and Jasper Jumper have been explained in detail and I will describe the Frankel appliance, the Twin Block, and the Activator/Bionator in this section.

The functional Regulator is a removable orthodontic appliance developed by professor Rolf Frankel of Germany. This appliance is used during the mixed dentition and early permanent

dentition stages to effect changes in anteroposterior, transverse, and vertical jaw relationships. There are 4 main types of Frankel appliances. Named the FR-1, FR-2, FR-3, and the FR-4. The Frankel appliance most commonly used in the U.S. today is the FR-2 funtional regulator.[3] It is the only tissue-borne functional appliance.[1,9]

It is important to know that the Frankel appliance is not an "orthodontic appliance" used for the correction of malocclusion, but rather to the functional disorder associated with dentoskeletal malformations. In developing a functional approach to orofacial orthopedics, it seems reasonable to follow the example set by the general orthopedists. Accordingly, the primary aim of treatment is to identify a faulty postural performance of orofacial musculature and to correct it by a functional therapy.[2]

The larger part of the Frankel appliance is confined to the oral vestibule, unlike the structures of conventional activators. The buccal shields and lip pads hold the buccal and labial musculature away from the teeth and investing tissues, eliminating any possible restrictive influence from this functional matrix.

Four possible influences are:

1)Mechanical factors which are associated with the development, ie. the influence of growth-linked changes in the size and shape of skeletal and soft tissue structures.

2)Mechanical factors of a functional nature, ie. the influence of physical function such as oral seal, mastication, deglutition, play of features and respiration.

3)Mechanical potential of the atmospheric pressure which, by acting on the soft tissue mass, is responsible to a considerable extent on the mechanical situation in the gnathic region.

4) the potential of the force of gravity, which exerts its influence especially on the tongue and mandible.

This is the thinking behind the endorsement of the insertion of

appliances in the vestibulum to enable us to exert a direct influence on the soft tissue.

It is believed that the formative changes achieved in the region of the tooth-bearing gnathic skeleton lead to spontaneous rehabilitation, as a result of a normalization of the soft tissues of lips, cheeks, and tongue, their position, their structure and their motor functions.[5]

Patients are usually treated using a three-phase technique. In the first phase, fixed appliances are limited to the incisors and molars in order to position the incisors correctly based on cephalometric analysis, facial height and curve of spee.[6] After this phase, appliances are removed and impressions are taken for phase two, which is the orthopedic phase. In this phase, the Frankel appliance is used to establish skeletal and muscular harmony. A third and final phase uses fixed appliances again to position and detail the dentition.[1]

This removable appliance is attached to the maxilla via a complex wire assemblage. The mandible, on the other hand, is not attached and must be positioned forward in a trough, formed by labial lip pads and an acrylic lingual pad, in order to close. The Functional regulator is truly an exercise device and achieves optimum results only if so used.[7]

The mechanical effect of the appliance in the vestibule is not directed to tooth and alveolar bone but rather toward the "capsular matrix". This therapeutic principle is different from that of common orthodontic appliances which directly apply pressure to the teeth and the supporting bony structures. Thus, the functional regulator enables us to realize the concept of orofacial orthopedics in which emphasis is changed to altering the conditions which determine the pattern of occlusal development rather than altering the occlusion directly. [2,8]

It is suggested that the lip pressure sensation provoked by the lingual shield will activate the proprioceptors in the gingiva and underlying periosteum and, as a result of feedback, stimulate the protractors to eliminate the disturbing signal. This movement of the mandible should be done in incremental steps similar to the way the mandible grows. Thus, a gradual displacement of the mandibular condyle away from the structures of the glenoid fossa is provided which corresponds to the gradual change in condylar position during normal growth.

The use of the Frankel appliance permits a gradual volumetric expansion of the orofacial capsule. Likewise, a gradual training of the orofacial musculature can be realized because the buccal shields are split horizontally and vertically into two parts. By opening the vertical split, the anterior segment, including lip pads and lingual shields can be moved gradually in an anterior direction. By using such a step-by-step advancement of the bite, the suspending musculature is not overstrained. Thus, inducing changes in the postural performance of the muscles suspending the mandible, the essential aim in a functional treatment of mandibular retrusion. Therefore, we may assume that, after the appliance has been discarded, these muscles are capable of providing the continuation of mandibular translation even in the post-retention period.[2]

The claimed benefits of the Frankel appliance are dramatic sagittal basal bone, dental and profile improvement, as well as restoration of normal perioral muscle function in the properly selected and treated cases. However, this appliance requires strict attention to detail and excellent technique in taking the impression, selecting a patient, and fabricating the appliance. If any of these are done incorrectly then all bets are off.[4]

In a study done by McNamara, comparing 58 class II patients treated with the Frankel appliance to an untreated Class II group, he found a slight decrease in the rate of maxillary growth and an increase in the rate of mandibular growth of approximately 50% per

year. In the untreated cases 2.5mm a year of mandibular growth occurred while in some Frankel cases 4 to 5mm a year occurred. According to McNamara, "there may be differences in the amount, rate, or direction of growth; but in my estimation, there is no question that you can alter growth. You can. the question is, how much can you alter condylar growth?"

In another study by McDougall PD, et al; Arch width development in Class II patients occurred much more in the molar and premolar region than in the canine region. [21]

The next appliance to be discussed is the twin block appliance. It was developed more than 20 years ago by Dr. William J. Clarke in Scotland and has gained popularity in North America. [20] This appliance was designed to be worn 24 hours per day and to be comfortable, simple, and aesthetically pleasing to the patient. It is used to treat Class II and Class III cases, but has gained popularity for its class II corrections. Twin blocks for this type of treatment are designed to place the mandible in a protrusive position by means of acrylic inclines on occlusal bite blocks. This differed from the first type of twin block, on which the blocks were angled at 90 degrees to the occlusal plane. This was diffficult for the patient and required a great deal of patient compliance for it to work. Today they are inclined at 70 degrees when engaged, and are much easier for the patient to tolerate. Many modifications of this exist.

The philosophy behind twin blocks is based on the proprioceptive stimulus to grow theory. In which, proprioceptive sensory feedback mechanisms control muscular activity and provide a deterrent to the full expression of mandibular bone growth. The unfavorable cuspal contacts of distal occlusion represent an obstruction to normal forward mandibular translation in function, and as such do not encourage the mandible to achieve its optimum genetic growth potential. Twin blocks aim to overcome these negative forces or contacts and improves the muscular environment. The first principle of this appliance design is simplicity, but if you

needed to correct a Class II Division 2 malocclusion, a sagittal screw may be added to advance the maxillary anterior teeth. Also, control of the vertical dimension is obtained by adjusting the thickness of the posterior occlusal inclined planes to control eruption.[11]

In a recent study,by Mills and McCullouch, on treatment effects of the twin block, results indicated that mandibular growth in the treatment group was on average 4.2mm greater than in the control group over the 14 month treatment period. In addition, some dentoalveolar effects in both arches contributed to the overjet correction. The twin block, unlike some of the other functional appliances, an average showed a slight inhibition of maxillary growth, as evidenced by a reduction of SNA as compared to a small increase in SNA in the control group. The mandibular unit length increased 6.5mm in the twin block group as compared to only 2.3mm in the control group. In the treatment group the overjet decrease 5.6mm of which, nearly two-thirds was from forward growth of the mandible. An overall distalization of maxillary molars of 1mm occurred in the treatment group as compared to mesialization of 1.5mm in the control group. In this study, approximately 50% of the molar correction was accomplished by skeletal improvement in the lower jaw and 50% by dentoalveolar change in the upper and lower jaws. [20] Long term effects have not been proven.

The forerunner of all functional appliances is generally considered the monobloc which was developed by Robin in the early 1900s. Functional appliances were not generally accepted until Andresen developed the Activator in the 1920s. This appliance was very popular in Europe and could advance the mandible several millimeters for class II correction. It also helped increase the vertical dimension.[4] They were simple appliances made of acrylic with a labial bow. In addition to the mandibular advancement, acrylic was selectively ground away to get individual tooth movement or selective eruption. Woodside and Harvold improved on the Andresen activator by adding shelves to allow lower posterior

eruption without allowing upper posterior eruption, and by adding displacing springs which forced the patient to actively maintain the appliance in place.[4] The Bionator is basically a cut-down activator that allows better patient compliance and acceptance because it is much smaller than the activators.[72] The Bionator was developed by Balters in the early 1950s. It was essentially a modified activator. According to Balters the equilibrium between the tongue and circumoral muscles is responsible for the shape of the dental arches and intercuspation. The functional space for the tongue is essential to the normal development of the orofacial system. This hypothesis supports the early function and form concepts of Van der Klaauw and the later functional matrix theory of Moss.[73]

As to whether the activator promotes growth, the answer according to Haupl , is qualified by the term "individual optimum." It is not possible to create a large mandible from a small one with an activator, but the optimum size consistent with morphogenetic pattern can be achieved for that individual patient.[75] Both skeletal and dentoalveolar changes can be achieved in activator functional appliance therapy.[74] DeVincenzo found that the increase in mandibular length during the functional appliance phase was pronounced and the rate of increase dramatic, but during the postfunctional appliance phase, the growth rate never reached that of the control group. In the final analysis, there was no long-term additional mandibular length over the controls after 4 years.[79]

Many orthodontists have elect to use elastics alone. Calvin Case (1847-1923) has been credited with bring intermaxillary elastics to the attention of the orthodontic community but he and Baker both claim to have been the first to invent them. The records are still unclear as to the truth of the matter.[80] Prior to the introduction of cephalometrics by Broadbent, intermaxillary elastics were assumed to work by increasing mandibular growth. Cephalometrics allowed the orthodontic community the ability to view pre- and post-treatment headfilms that indicated that we did not increase mandibular growth but advanced the mandibular teeth en masse,

placing them in a protrusive position.[81] Oppenheim found, intermaxillary elastics, while providing dental movement, were not producing the improved skeletal effects they were believed to be causing. He wrote that headgear would be valuable to treatment and that it would produce better orthopedic results if it were worn intermittently rather than continuously.[27]

As you have seen, many of these appliances use different means to reach their goal of correcting malocclusions. Different philosophies exist on why growth occurs or why it does not. One thought is that the lateral pterygoid muscle has a decisive role in this growth and forward posturing of the condyle activates the superior head of the lateral pterygoid . In young individuals this induces a cell proliferation in the condyle and a growth response.[4] Others say that the growth potential is there but that it is being held up by physiological barriers such as occlusal forces and soft tissues.[11] Many of the Class II correction modalities have induced skeletal changes but none of them have shown a stable long-term skeletal change. In this review of the literature I conclude that with few exceptions the results obtained with all previously mentioned appliances are merely short-term and the long-term effects are largely dentoalveolar. The skeletal effects that do remain long-term post-retention would have taken place regardless of which appliance was used or if any appliance was used at all.

Airway

No practice involving health care for children in the 20th century has excited more heated controversy among health professionals than has surgical removal of the tonsils and adenoids.[82] Tonsillectomy has been know as a surgical procedure for at least two millennia, a technique for the operation having been described by Celsus as early as 50 A.D.[83] Tonsillectomy has long been indicated by physicians as therapy for recurrent throat infections. Unlike Tonsillectomy,

Adenoidectomy was probably not undertaken until the latter half of the 19th century, when Wilhelm Meyer of Copenhagen suggested that adenoid vegetations were responsible not only for nasal symptoms but also for impaired hearing.[84] Adenoidectomy has been found to be an effective treatment with regard to disease of the middle ear. [82] The two operations began increasingly to be carried out together early in the 20th century, as the then popular "focus of infection" theory attributed various systemic disorders. [82] According to Rubin, an adenotonsillectomy is indicated if lymphoid tissue is causing nasal airway obstruction. [85] The role of tonsillectomy and adenoidectomy in the medical field was growing more complex and controversial. Contentions by orthodontists that sustained mouth breathing due to large adenoids may cause abnormalities in the growth and development of the facial skeleton and dentition was adding to the controversy.[90,91,93] The benefits of Tonsillectomy and Adenoidectomy for medical reasons has divided the Otolaryngology field into two camps. Orthodontists have joined in the debate and it is not surprising to find physicians unresponsive to suggestions by the orthodontist that such surgery should be considered.[94]

Nasal airway obstruction is thought by many to be the leading cause of developmental deformities such as "long face syndrome", steep mandibular plane angles, prognathisms, asymmetries, anterior and posterior openbites and some TMJ problems.[3] The etiology of nasal airway obstruction may be congenital, acquired, or developmental. The congenital causes include choanal atresia, which can be bony or membranous, and hypoplastic external nares. Acquired and Developmental causes include deviated septa, extensive nasopharyngeal lymphoid tissue, perennial allergic rhinitis, neoplasms, polyp formation, trauma, and iatrogenic. Perennial allergic rhinitis being the most common cause.[85]

How does a nasal airway obstruction cause a malocclusion? The thinking goes like this, for example: Obstruction of the nasal airway is followed by the lowering of the mandible to establish an oral airway. This changes the relationship of the craniomaxillary complex to the mandible by causing the mandibular elevators to relax and change their physiologic rest position.[86] Harvold and associates have shown that obstruction of the nares in monkey is followed by the recruitment of muscles to lower the mandible and spread the lips to establish an oral airway.[87] The suprahyoids contract and the masseter, internal pterygoid, and temporal muscles relax, permitting the mandible to rotate clockwise. Upon swallowing, many mouth breathers do not elevate the mandible to exert mechanical force between the upper and lower jaws.[88,113] As a result, some feel they may be at risk of developing the "long face syndrome." This lack of contact during swallowing can cause supereruption of the teeth, excessive vertical alveolar growth or both. Linder-Aronson's studies on human subjects with enlarged lymphoidal tissues have suggested a relationship between respiratory pattern and dentofacial form.[89,90,91,92] Tonsillectomy and adenoidectomy have been suggested as therapy for correction and/or the prevention of "long face syndrome" by relieving the obstruction caused by these enlarged or inflamed lymph tissues. Not all individuals with enlarged lymphoid tissues or blocked nasal airways develop "long face syndrome" even if they do become mouth breathers. It seems that the primary cause of "long face syndrome" results from the chronic downward positioning of the mandible. Those who change mandibular position only while taking a breath and then reposition the mandible closed, back into occlusion, do not develop long facies.[87, 102, 103]

There are several studies that suggest there exist positive relationships between airway obstruction and altered dentofacial

development. Linder-Aronson has shown cephalometrically that the mean mandibular plane angle flattened slightly when a group of mouth breathers became nasal breathers after adenoidectomy. The mean changes, while significant, were very small.[95] Linder-Aronson and Woodside studied serial frontal and lateral head films from the Burlington Growth Study. They concluded that there is support for the concept that some facial characteristics previously thought to be skeletal or genetic in origin may also be influenced by environmental impact.[96] Linder-Aronson presented a case of monozygotic twins in which only the twin with nasal obstruction developed excessive anterior facial height. [92] Quinn has assigned nasal airway obstruction as the major cause of mandibular prognathism, facial asymmetries and vertical dysplasias.[97] Similarly, Linder-Aronson has shown that children with nasopharyngeal obstruction associated with enlarged adenoids and a demonstrable reduction in nasal airflow have larger total and lower anterior facial heights, more retrognathic mandibles, and steeper mandibular planes when compared to controls without nasorespiratory problems.[90] Rickets states that he followed a group of 40 patients after the surgical removal of adenoids and tonsils but employed no orthodontic treatment for several months. Three of the patients showed spontaneous correction of their cross-bite with no orthodontic treatment.[116] Vargervik and associates have also shown in primates that the increase in lower face height and steepness of the mandibular plane that followed the establishment of oral respiration partially recovered after the re-establishment of normal respiration.[104] Finally, Ung's research showed a weak correlation between mouthbreathers and Class II skeletal pattern and retroclination of the maxillary and mandibular incisors.[112]

Contrary to the above studies, Horwitz and Hickson conclude that objective measurements have not sustained the hypothesis

that mouthbreathing is a causal factor in orthodontic anomalies.[98] Backlund in 1963 suggested the use of a cold mirror to test condensation patterns in an effort to establish nasal respiration but failed to find significant correlation between adenoids and mouth breathing.[110] In Linder-Aronson's study of post-adenoidectomy patients it is interesting to note that the catch-up was never complete, and the magnitude of the differences attributed to adenoid removal are far too small to make a clinically significant difference in terms of subsequent growth and development.[109] Humphreys and Leighton failed to find significant evidence of a relationship between mouth breathing and dentofacial form. Mouth breathing was found to be associated with all types of malocclusion as well as with normal occlusions, as supported by Howard and Leech.[99,100,101] Linder-Aronson found that only 25% of patients needing adenoidectomy were of the morphologic type known as "adenoidal facies"[90]

According to Vig, there can be no excuse at present for the prophylactic use of surgery to improve either facial growth nor nasal respiration for orthodontic reasons because it is unsupported by research.[109] O'Ryan agrees stating, "while a relationship between nasal obstruction and mouth breathing cannot be denied, a causal association between mouth breathing and altered dentofacial form is unproven."[117]

One of the most difficult aspects of this controversy centers around the methods of evaluating the patient's airway. There are many aspects to airway evaluation. The orthodontist must evaluate the airway at the nares, the septa, lymphoid tissue (ie. tonsils and adenoids) and pharyngeal region. All of these are equally important. Constriction at any of these points can cause the patient to develop a mouth breathing pattern. If a positive correlation between mouth breathing and altered dentofacial development is found, this examine finding could potentially play

a major role in orthodontic treatment planning.

The panoramic headplate, a tomograph made at the level of the central incisors, can be helpful in assessing deviation of the nasal septum. Direct examination with a nasal speculum is essential. Deviation is invariably accompanied by hyperplasia of the turbinates on the concave side.[85] Schulhof in 1978 claimed that the use of computer-aided cephalometric analysis provides a definitive method for assessing airway impairment due to adenoids.[108] Many problems exist with this technique including assuming three dimensional characteristics to a two dimensional radiograph. It has been concluded that cephalometric radiographs alone are inadequate for assessing airway impairment. Studies of variations in adenoid shadow size on radiographs have failed to show any value as useful predictors of respiratory mode. Rhinomanometric nasal pressure-flow data have also been used, but correlations of this type of evaluation and airway capacity are insignificant.[109]

Direct observation can provide the practitioner with information about severe constrictions of the nares and blatant mouth breathing. It was suggested by Bridger that the nares may be a significant factor in controlling respiratory airflow through the nose. Obviously, if the greatest constriction of the entire nasal passage exists at the nares, it is irrational to blame more posterior anatomic structures, such as turbinates or adenoids, for the existence of significant nasorespiratory impairment.[109,111] The clinician should be conscious of this fact, as to not refer the patient for adenotonsillectomy while the obstruction lies at the nares.

Backlund in 1963 suggested the use of a cold mirror to test condensation patterns in an effort to establish nasal respiration, but failed to find significant correlation between adenoids and

mouth breathing.[110]

Other advances such as Computed Tomography(CT) provide addition means of airway evaluation. CT is a radiographic imaging technique based upon computer assessment of radiation-absorbing characteristics of the various tissues of the body. The sensitivity of CT makes it possible to identify hard and soft tissues in multiple, sequential, radiographic slices(tomograms). The location, size and shape of these tissues can be evaluated.[114] With this technology it is now possible to assess accurately *in vivo* the three-dimensional relationship of facial structures including the turbinates, tonsils, adenoids, and the entire airway.[115]

Other methods of evaluating respiration have been developed and modified but very few if any are appropriate or practical for orthodontists.

Vig suggests that unless the total volume of air being breathed in and out is known, the relative contributions of the oral and nasal airflow to the individual's breathing mode cannot even be inferred.[106,107] The best method may be to determine whether or not the patient can inspire comfortably through both nasal cavities without effort.[97]

Once a reasonable diagnosis has been established for the removal of tonsils or adenoids, the clinician must be aware of certain contraindications. Contraindications to surgery are in four general categories: Velopharyngeal, hematologic, immunologic, and infectious. Velopharyngeal insufficiency, including cleft palate, constitutes a contraindication to adenoidectomy. Hematologic conditions such as anemia or hemophilia are relative contraindications. Long lasting allergy that has been left untreated is another relative contraindication. Finally, tonsils and

adenoids should not be removed until acute infection is under control.[105]

Elective surgeries should be minimized. The death of a child as a consequence of tonsil or adenoid surgery is tragic in any circumstance, but particularly so if, as is usually the case, the operation was elective in nature.[105]

It is by no means clear to what extent craniofacial morphology is influenced by respiratory mode. The orthodontic diagnosis of airway obstruction and enlarged tonsils and adenoids is at present very subjective and evidence relating dentofacial form to breathing patterns is inconclusive.[94] Finally, when the data concerning the presence of adenoids and their relation to nasorespiratory function and dentofacial morphology is critically examined, it can be seen that the amount of nasal obstruction does not appear to be related to nasal airflow nor to dentofacial morphology. Whether the characteristic facial type which has been observed in patients with hypertrophic adenoids is hereditary, acquired secondary to musculoskeletal forces, or a combination of these remains to be determined.[117]

Research Objectives

The objectives of this research were twofold. First, to obtain a representative sample of current treatment modalities for Class II correction used by practicing orthodontists in Oregon and Washington. Their belief as to the ability of these modalities to correct the malocclusion beyond the patient's innate genetic potential was also questioned. Next, it was desired to establish whether these treatment methods are supported by current scientific research. Also, the practitioner's beliefs concerning airway, its contribution to facial disharmony, and their role in

recommendation/referral to an ear, nose, and throat specialist were surveyed. Finally, results were analyzed for differences based on location and experience, measured by years in practice.

Materials and Methods

Surveys (fig. 1) were sent to all practicing orthodontists of record in the states of Oregon and Washington. 125 were sent in Oregon and 216 were sent to Washington. 341 were mailed out in all. A self addressed, stamped envelope was mailed along with the survey in hopes to increase the number of responses. No markings were made on the survey and anonymity was maintained to avoid bias. The names of all orthodontists practicing in the states of Oregon and Washington were obtained from the American Association of Orthodontics for a nominal fee.

The 242 respondents were divided into four groups based on experience. Experience was determined by number of years in practice. Group 1 was less than five years in practice, group 2 was 6-15 years of experience, group 3 was 16-25 years in practice and group 4 had more than 25 years of experience. Each of the groups were totalled, averaged and compared to each other based on the following: 1) Class II correction modalities used 2) if they felt the appliances they use can cause increased growth beyond the patients genetic potential 3.) if they routinely evaluate airway 4.) whether or not the practitioner recommends tonsillectomy/adenoidectomy 5.) if the orthodontist has an ENT to whom he refers on a regular basis. Interstate differences were also compared. When filling in the Class II correction modality section, participants were given five choices or categories. The first was a zero which meant that the practitioner does not use this appliance in any of his cases. Selection of a particular appliance between 1% and 25% of the time was given a category score of 1 on the histogram. If the appliance was chosen between 26% and 50% of the time, a

score of 2 was given. Category 3 means the appliance was chosen between 50% and 75%, and category 4 means the appliance was used in greater than 75% of the cases.

Fig. 1

Class II correction modalities

What percentage of the time do you use the following appliances when correcting a Class II malocclusion without surgery?

(Circle all that apply)

Herbst Appliance

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Activator/Bionator

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Jasper Jumper

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Other Functional Appliances

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Headgear

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Elastics alone

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

Extractions

Adults	Zero	1-25%	26-50%	51-75%	76-100%
Children	Zero	1-25%	26-50%	51-75%	76-100%

What percentage of your practice consists of adults?

What is your **main** Class II correction modality:

For the deep bite case?_____

For the openbite case?_____

Where did you learn about this modality?_____

Do you feel that you are getting skeletal changes **beyond** the patient's genetic potential with any of these appliances? *Answer below*

*(circle one)*In children? Yes or No

If yes which appliances?_____

In adults? Yes or No

If yes which appliances?_____

•Part 2

Airway

Do you routinely evaluate the patient's airway?_____

If yes, What do you use to evaluate the airway:*(check all that apply)*

_ Visual Inspection
_ Lateral Ceph
_ Tidal Volume
_ Patient History
_ Other

Do you think that airway problems contribute to openbites?_____

Do you think that airway problems contribute to "long faces"?_____

Do you think that airway problems contribute to steep mandibular planes?

_____

Do you have an ENT physician to whom you refer?_____

Would you likely ever recommend removal of Tonsils/ adenoids?_____

How many years have you been in practice?_____

In what state do you practice?_____

Results

Adult Class II Correction Modalities

See Chart 1

Modalities chosen by group 1 (less than 5 years in practice) were on average dominated by extraction as the method of choice for Class II correction with a category score of 2.09. Elastics alone had a category score of 1.81, followed by headgear with a score of 0.41, and jasper jumper with 0.28, other functional appliances with 0.09, and finally Herbst and Activator/Bionator, both had a score of 0.0. Group 2 (5 to 15 years in practice) was similar to the first group in that extractions and elastics alone were predominant with category scores of 1.78 and 1.61 respectively. Headgear and jasper jumper were next with scores of 0.37 and 0.39 respectively, followed by Herbst (0.15), activator/Bionator and other functional appliances tied for last (0.10). Group 3 (16 to 25 years in practice) was consistent with the other groups. Extractions(1.81) were followed by elastics alone(1.41), then headgear (0.64), jasper jumper and other functional appliances (0.12). Herbst (0.09) was among the lowest scores but activator/bionator scored 0.0. Group 4 (greater than 25 years in practice) was led by extractions (1.82), elastics alone (1.69), and headgear (0.77). Other functional appliances (0.41), jasper jumper (0.18), Herbst (0.1), and activator/bionator (0.05) were among the least chosen.

See Chart 3

Interstate comparisons were made within all 4 groups and the results were similar for both Oregon and Washington respondants.

In group 1, differences lie in the use of the Herbst appliance with Oregon responding with a category score of 0.0 and

Washington 0.14. Headgear and elastics alone also were separated by 0.35 and 0.27 respectively, with the higher score being from the Oregon group. Group 2 showed a variation in the pattern with Oregonians using the Herbst 0.24 units more than Washington practitioners. Elastics alone was used more by Washington Practitioners than Oregon Orthodontists (1.26-1.83) Group 3 showed an equal but opposite change from that of Group 2. (Elastics alone 1.57 Oregon and 1.25 Washington). Lastly, group 4 was similar except for the use of the Herbst appliance which showed more use of the appliance by Oregonians (0.20) than Washingtonians (0.00)

Children Class II Correction Modalities

See Chart 2

A different pattern was established with regard to Class II correction modalities in children. In group 1, headgear dominated with a category score of (2.16). Elastics alone, extractions and Herbst showed scores of 1.38, 1.25, and 1.125 respectively. Other functional appliances, jasper jumper, and activator/bionator followed with category scores of 0.5, 0.44, and 0.38.

Group 2 scores were in the exact same order as group 1 but showed the following category scores: Headgear (2.02), elastics alone (1.29), extractions (1.20), herbst (1.14) which were among the highest scores in group 2. While other functional appliances (0.61), jasper jumper (0.53) and activator/bionator (0.37) scored the lowest. The pattern changed slightly in group 3 with activator/bionator (0.67) scoring higher than other functional appliances (0.47) and jasper jumper (0.41) while still scoring less than headgear (2.03), elastics alone (1.26), Herbst (1.21), and extractions (1.12). Group 4 also showed a variation in pattern with other functional appliances (0.95) scoring higher than Herbst (0.65), activator/bionator (0.55), and jasper jumper (0.35) but less than headgear (2.0), elastics alone (1.56), and extractions (1.38).

See Chart 4

Interstate comparisons revealed differences between Oregon and Washington practitioners in groups 1,2, and 3 with respect to the Herbst appliance. Oregon Orthodontists scored 0.73, 1.52, and 1.40 while Washington scored 1.33, 0.89, and 1.0. In group 1, elastics alone scored 1.82 by Oregon and 1.14 by Washington. Group 2 showed a difference between other functional appliances (0.83 Oregon , 0.47 Washington) and Headgear (1.57 Oregon, 2.31 Washington). Group 3 scored differently for headgear (1.93 Oregon, 2.14 Washington) as well as Activator/Bionator (0.40 Oregon, 0.96 Washington). There was a difference in scores for Activator/Bionator in group 4 also,(0.35 Oregon, 0.75 Washington). Group 4 results for other functional appliances (1.15 Oregon, 0.74 Washington) and extractions (1.20 Oregon, 1.58 Washington) were slightly inconsistent comparatively.

Genetic Potential

See Chart 5

All groups showed similar results in their belief or disbelief of obtaining growth beyond the patients genetic potential. Group 1 responded on average that they obtained growth beyond the patient's genetic potential in 56.2% of children and just 3.1% of adults. Group 2 responded 53.3% in children and 1.7% in adults, Group 3 responded 46.4% in children and 1.8% in adults, and Group 4 responded 35.9% in children and 0.8% in adults.

See Chart 6

Oregon respondents in group 1 were very similar to Washington respondents, with regards to children, reporting

55% and 57% respectively. Group 2 responded with a 12% discrepancy (46% Oregon and 58% Washington) as did group 4 (40% Oregon, 30% Washington). Group 3 also showed a variation, although to a lesser degree, with an 11% difference (52% Oregon, 41% Washington). In the Adults section, Washington groups 1,2,and 3 reported no effect on growth past the patient's genetic potential, while Oregon responded positively with 9%, 4% and 3% respectively. Group 4 showed a 6% discrepancy (5% Oregon, 11% Washington).

Airway

See Chart 7

50% of Group 1 reported that they routinely evaluate airway, while 70% of group 2, 65.5% of group 3, and 56.4% of group 4 do so routinely .

50% of Group 1 orthodontists responded that they would likely recommend tonsillectomy/adenoidectomy to a patient and 21.9% have an ENT physician to whom they refer. 66.7% of group 2 stated that they would likely recommend T/A to a patient and 49% said they have an ENT physician to whom they refer. 73.7% of group 3 responded that they would likely recommend tonsillectomy/adenoidectomy to a patient and 70.7% have an ENT physician to whom they refer. 62.5% of group 4 stated that they would likely recommend T/A to a patient while 59% say they have an ENT physician.

See Chart 8

Interstate comparisons for airway evaluation revealed a large difference between Oregon and Washington practitioners. The results showed an overall trend toward the Oregon group scoring higher than Washington in most

categories. When questioned regarding the routine evaluation of airway during exams, more Oregonian practitioners in all experience levels responded positively than did Washington practitioners by 6-9%, and by 44% for practitioners with > 25 years experience. 45-79% of all respondents recommend tonsillectomy/Adenoidectomy to their patients when they deem it necessary. Oregon participants responded positively more often than Washington participants in all groups with the exception of group 1. In response to whether or not they have an ENT physician to whom they refer, answers ranged from 18-70% of Oregonians and 24-71% of Washingtonians who said they did. Recent graduates made up the low end of the range for both groups (see Table 1).

Discussion

Adult Class II Correction Modalities

The results from this portion of the survey showed that extractions were the most often used treatment modality for Class II correction in Adults in all groups. The closest score category was 2 which would place this data in the 26%-50% category of use. This translates to: extractions are used in approximately 26-50% of class II correction modalities in adults.

Elastics alone were used to a slightly lesser degree as the method of class II correction in approximately 1-25% of the adult class II patients. Headgear was the third most often used modality, with its prevalence increasing amongst practitioners with over 15 years experience. Herbst and Activator/Bionator use was more or less non-existent with the most recent graduates. On average, the jasper jumper, headgear and other functional appliances were used less than 1% of the time by all respondents (see chart 1).

It is interesting to note, when comparing Oregon and Washington class II correction modalities that on average, the

Oregon practitioners chose extraction over all other options more often than did the Washington orthodontists. For practitioners with 6-15 years of experience, elastics alone was used more often by the Washington respondents. This was due to the increased use of Jasper Jumpers and Herbst by the Oregon practitioners in this group (see chart 3).

Children - Class II Correction Modalities

Practitioners reported a greater variety of treatment modalities used for children than they did for adults. Headgear was the most often chosen correction modality amongst all respondents. It fell in range of category 2 which translates to use in approximately 26-50% of the cases. Elastics alone was the next most frequently used correction modality in all groups. Extraction and Herbst were also frequently used with the only exception being less Herbst use by practitioners with greater than 25 years of experience.

Statewide trends in Class II treatment modalities in children vary with respect to years of experience. The most recent graduates practicing in Oregon used elastics alone, second only to headgear, as their main Class II correction modality more often than did the Washington graduates. Whereas Washington graduates tended to use the Herbst appliance as their second choice. Respondents from Washington with 6 to 15 years of experience chose headgear as their treatment of choice. Oregon graduates in the same group used headgear and the Herbst appliance with approximately the same frequency. Of the orthodontists with 16 to 25 years of experience, the main Class II corrector for respondents from both states was headgear. The next most frequently used appliance by the Washington group was elastics alone followed closely by extraction. The Oregon group chose the Herbst as their next most frequently used correction modality. Finally, the practitioners with over 25 years

of experience prefer headgear for the majority of their treated cases, while use of the Herbst appliance was less evident. Extraction use in the Washington group rose in comparison to previous groups. The Activator/Bionator appliance was used more frequently by Washington practitioners, while Oregon respondents used more "other functional appliances".

Beyond Genetic Potential

One of the most interesting findings of the survey was related to the belief that practitioners can obtain growth beyond a patient's genetic potential. Chart 5 shows the percentage of practitioners at each experience level that believe it is possible to obtain growth beyond genetic potential through orthodontic treatment. While less than 10% or respondents felt that this was possible in adults, between 36 and 56% believed that growth beyond a patient's innate genetic potential was possible. This percentage gradually decreased with experience in regards to adolescent treatment. There was little difference between Oregon and Washington respondents. 14% more Washington practitioners, with 6 to 15 years of experience, believe it is possible to enhance growth in children beyond their genetic potential. 5 percent of Oregon practitioners with greater than 25 years of experience believe adults can grow beyond genetic potential while 11% of Washington practitioners agreed.

The portion of the survey that addressed genetic potential was cause for much feedback, both positive and negative, from respondents. Many practitioners felt that the questions in this section were too vague or ill-defined. There was also discrepancy among the respondents who felt that growth could be pushed beyond genetic potential, and the treatment modalities of choice that would correspond to this belief. For example, the practitioners with greater than 25 years of experience on average preferred extractions and Class II elastics

for their main Class II correctors with functional appliance use at a minimum, while they were also the group that showed the highest percentage of respondents who believed it was possible to obtain growth in adults beyond the genetic potential.

Airway Evaluation and Management

Chart 7 shows that 50% or more of the survey respondents routinely evaluate airway. Interestingly, of those, almost all of them recommend tonsillectomy/adenoidectomy. This suggests that practitioners are evaluating airway mainly in those cases for which they feel that airway has had a potential etiologic role in the development of the malocclusion. Many respondents made notes as such on the survey. Having an ENT physician to whom they generally refer generally increased with years in practice.

This area of the study received a great deal of interest, and would have been better structured for more complete data analysis with more specific questions. It would have been interesting to evaluate for which types of cases practitioners feel compelled to examine airway, if they do in fact do this on a case by case basis. There also should have been a distinction between whether or not practitioners refer to an ENT physician for an evaluation, or for a specific procedure. Finally, as the number of years in practice increases, the trend toward recommending tonsillectomy and/or adenoidectomy increases, and diminishes again at the 25 year mark.

Statewide, more practitioners in all experience levels in Oregon routinely evaluate airway. Practitioners with greater than 25 years of experience in Oregon more than double the practitioners in Washington with regards to those who routinely perform this evaluation. It was also shown that Oregon practitioners in the 6 to 15 year experience group recommend tonsillectomy and/or adenoidectomy much more frequently than

their colleagues in Washington. Recent graduates in Washington were more likely to refer to an ENT, and were more likely to have an ENT to whom they refer.

This survey could have been improved by narrowing the percentage range for the use of each appliance. The current range of 25% makes it very difficult to decipher exactly how often the appliance is actually used. A better method would have been to ask fill in the blank questions for the practitioner to answer. Another area of the survey that could have been improved was the "Beyond genetic potential" area. Many of the respondents made notes on that question that said "too vague", "too hard" or "Define Genetic potential". Clarification of this point would have increased the response to that question. Words like "routinely", "likely", and "feel" could have been eliminated to make the responses more consistent. A larger sample size including states outside of the NorthWest would have made this paper more interesting interesting.

Conclusion

A survey was sent to 341 practicing orthodontists in Oregon and Washington in order to obtain information on preferred Class II treatment modalities in children and adults. 242 were filled out and returned. The role of airway and the practitioner's use of an airway examination was also investigated. Finally, practitioners were questioned as to their beliefs regarding their ability to influence growth in children and adults beyond the patient's genetic potential. When treating Class II malocclusions in adults, the respondents predominantly chose extraction as the treatment of choice followed by elastics alone. This was consistent in both states. The treatment modality of choice for Class II correction in children for the orthodontists surveyed in both Oregon and Washington was

headgear, followed to a lesser extent by elastics alone, extractions, and finally the Herbst appliance.

The majority of orthodontists that filled out the survey felt they could increase growth beyond genetic potential. This number decreased with experience but interestingly the number of practitioners that felt they could affect adult growth beyond genetic potential increased with experience.

On average more than 60% of the respondents said they evaluate airway routinely and would likely recommend Tonsillectomy and/or adenoidectomy. Most had an ENT physician to whom they refer, as well. Oregon orthodontists were more likely to routinely evaluate airway than the Washington orthodontists. This discrepancy increased as the years in practice increased. Washington Practitioners were more likely to refer for Tonsillectomy/adenoidectomy than were the Oregon respondents from 0 to 15 years of experience but this number leveled out as experience increased.

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CHART 1

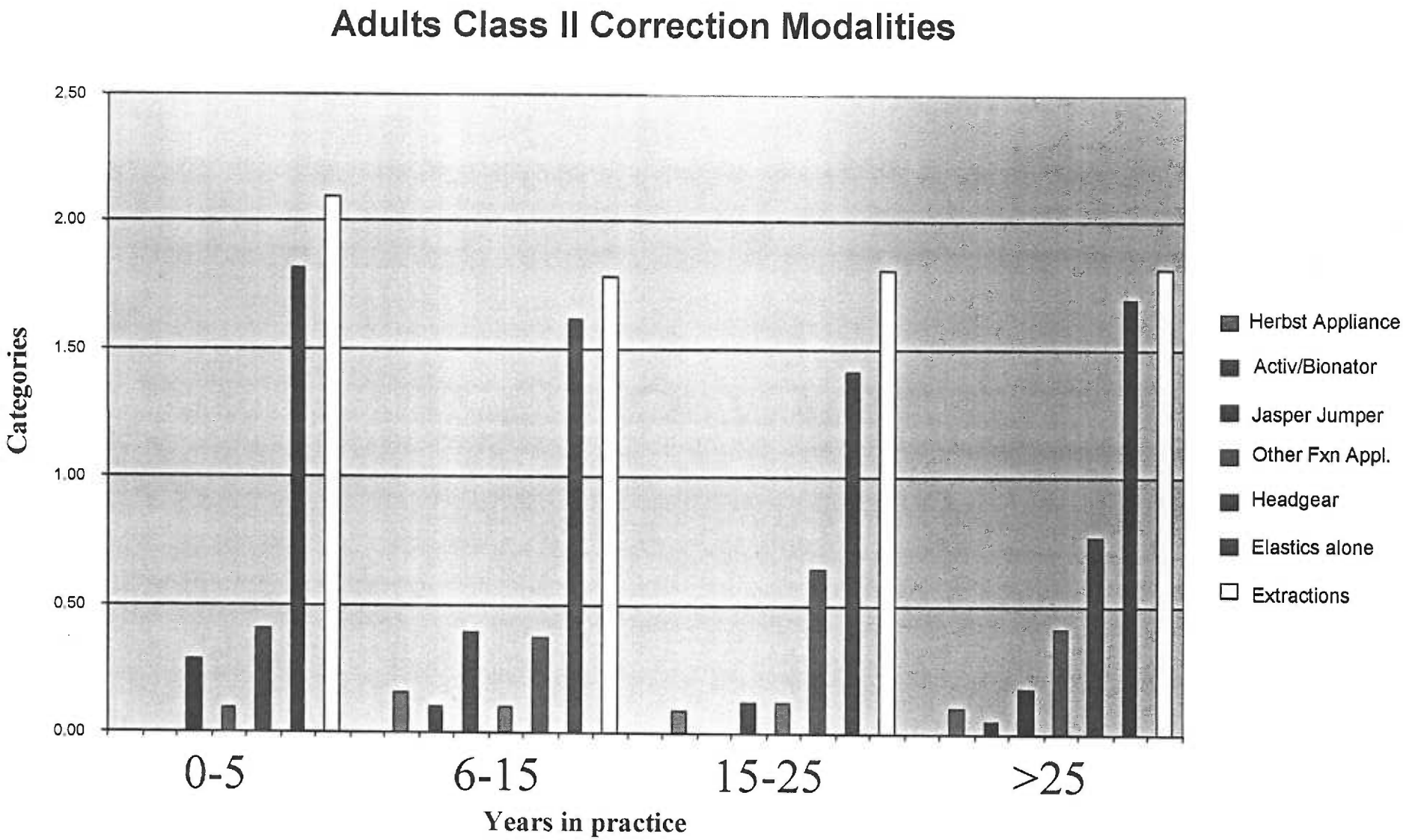

Chart 1 shows the frequency of appliances used based on experience. A category score of 1 means the appliance was chosen between 1 and 25% of the time. A category score of 2 means the appliance was chosen between 26 and 50%, a score of 3 means the appliance was chosen between 51 and 75%, and a score of 4 means the appliance was used in greater than 75% of cases.

CHART 2

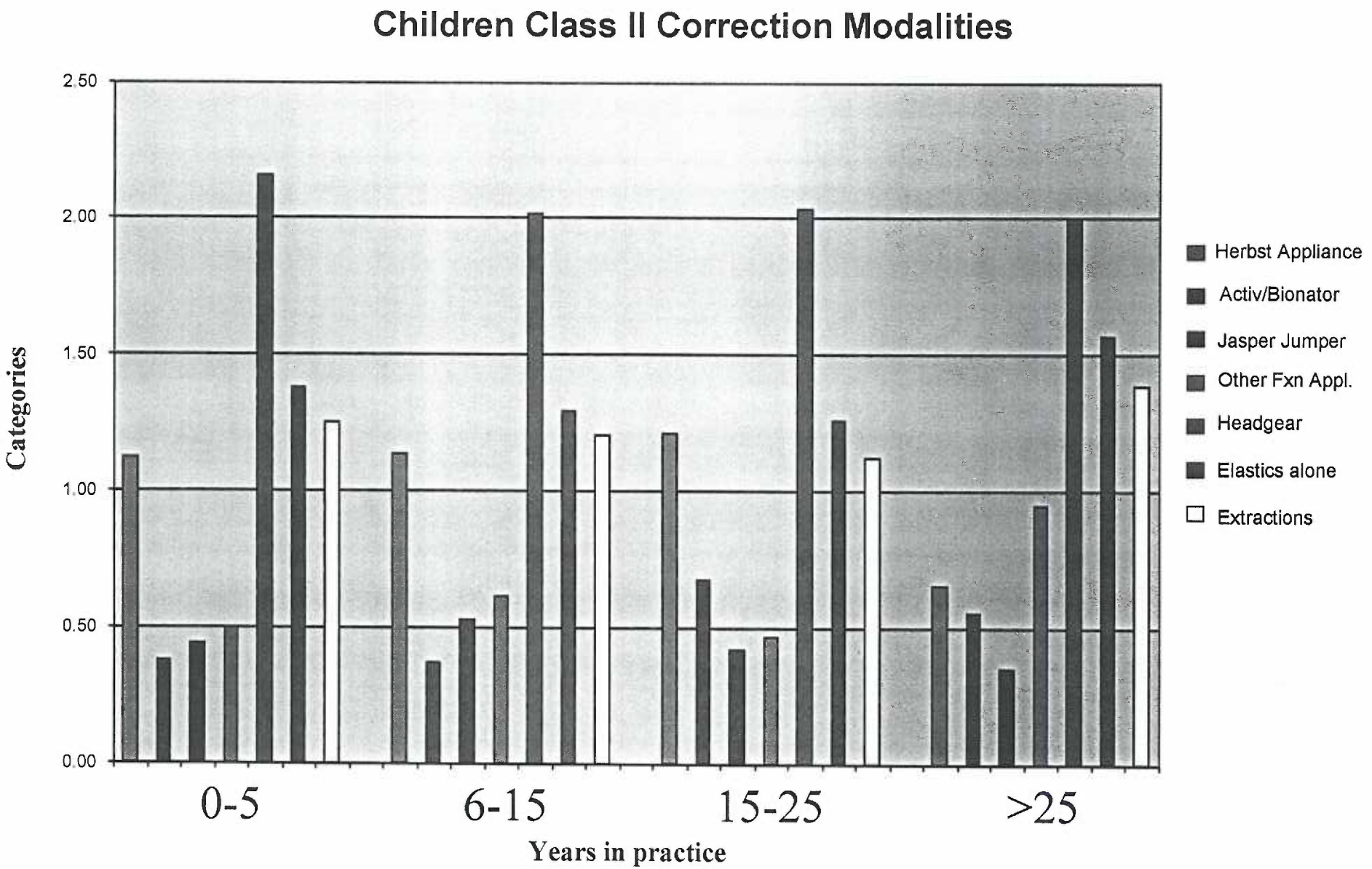

Chart 2 shows the frequency of appliances used based on experience. A category score of 1 means the appliance was chosen between 1 and 25% of the time. A category score of 2 means the appliance was chosen between 26 and 50%, a score of 3 means the appliance was chosen between 51 and 75%, and a score of 4 means the appliance was used in greater than 75% of cases.

CHART 3

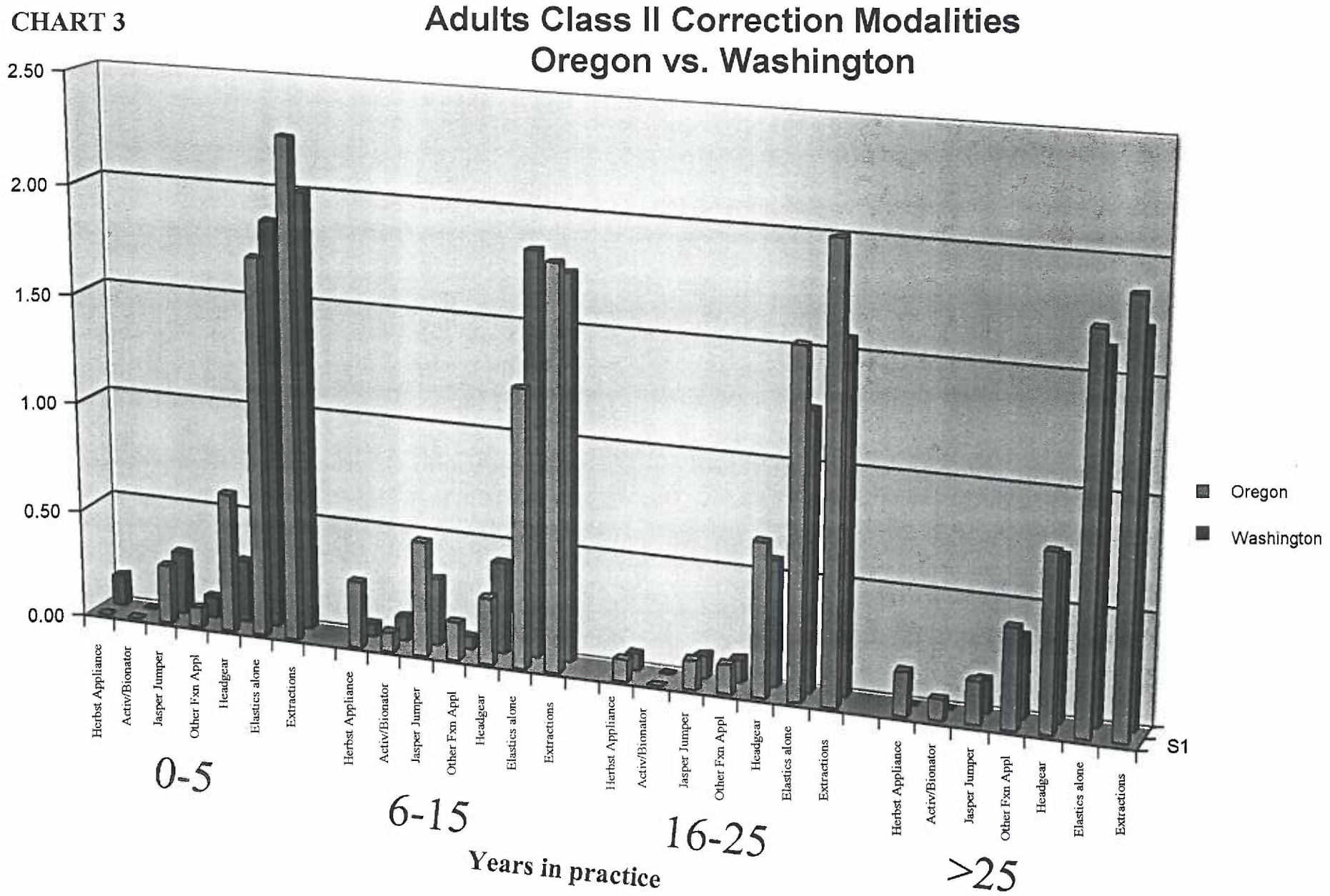

Chart 3 compares the frequency of appliances used based on experience between Oregon and Washington clinicians. A category score of 1 means the appliance was chosen between 1 and 25% of the time. A category score of 2 means the appliance was chosen between 26 and 50%, a score of 3 means the appliance was chosen between 51 and 75%, and a score of 4 means the appliance was used in greater than 75% of cases. Blue bars represent orthodontists practicing in Oregon while red bars represent those practicing in Washington.

CHART 4

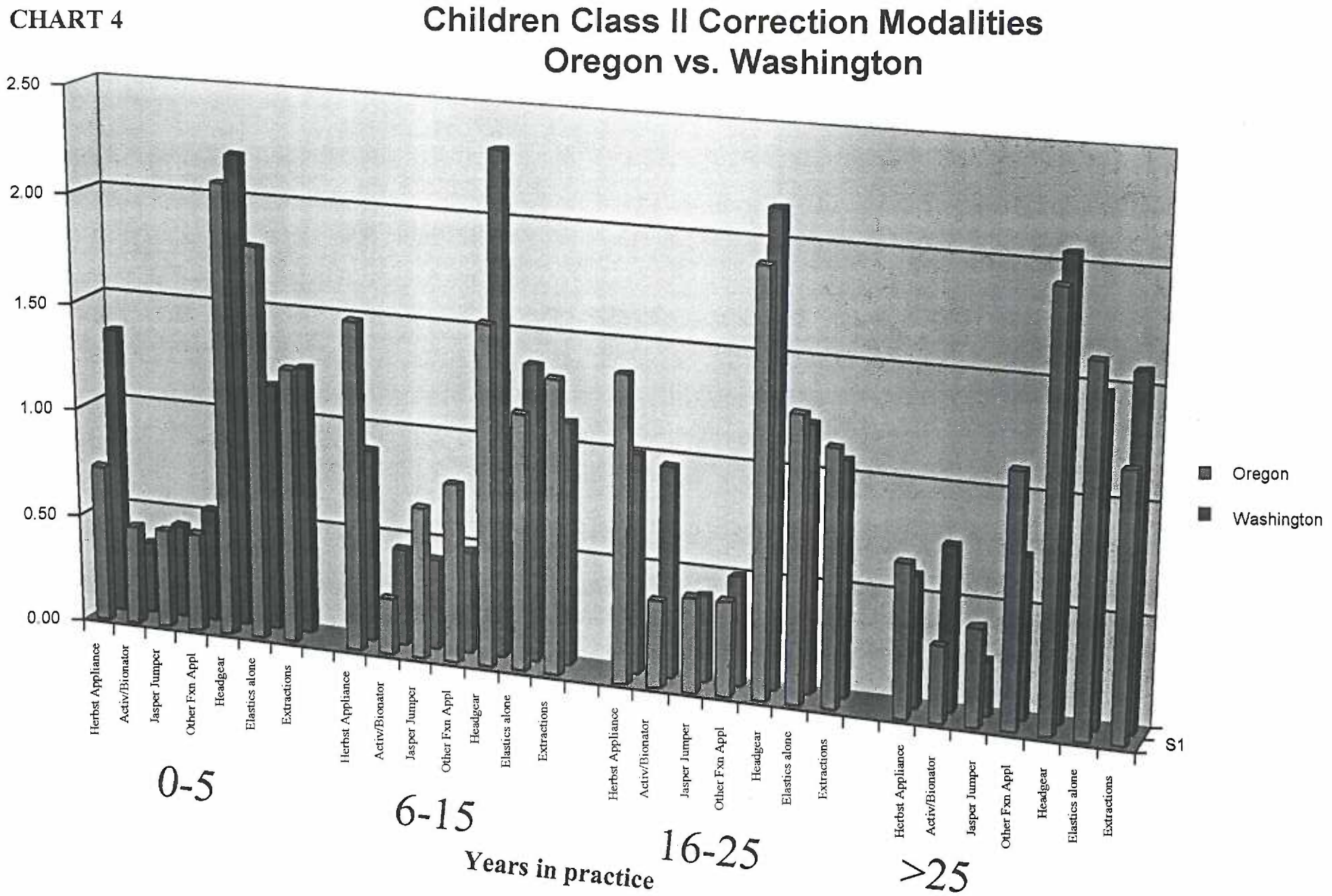

Chart 4 compares the frequency of appliances used based on experience between Oregon and Washington clinicians. A category score of 1 means the appliance was chosen between 1 and 25% of the time. A category score of 2 means the appliance was chosen between 26 and 50%, a score of 3 means the appliance was chosen between 51 and 75%, and a score of 4 means the appliance was used in greater than 75% of cases. Blue bars represent orthodontists practicing in Oregon while red bars represent those practicing in Washington.

CHART 5

Beyond Genetic Potential

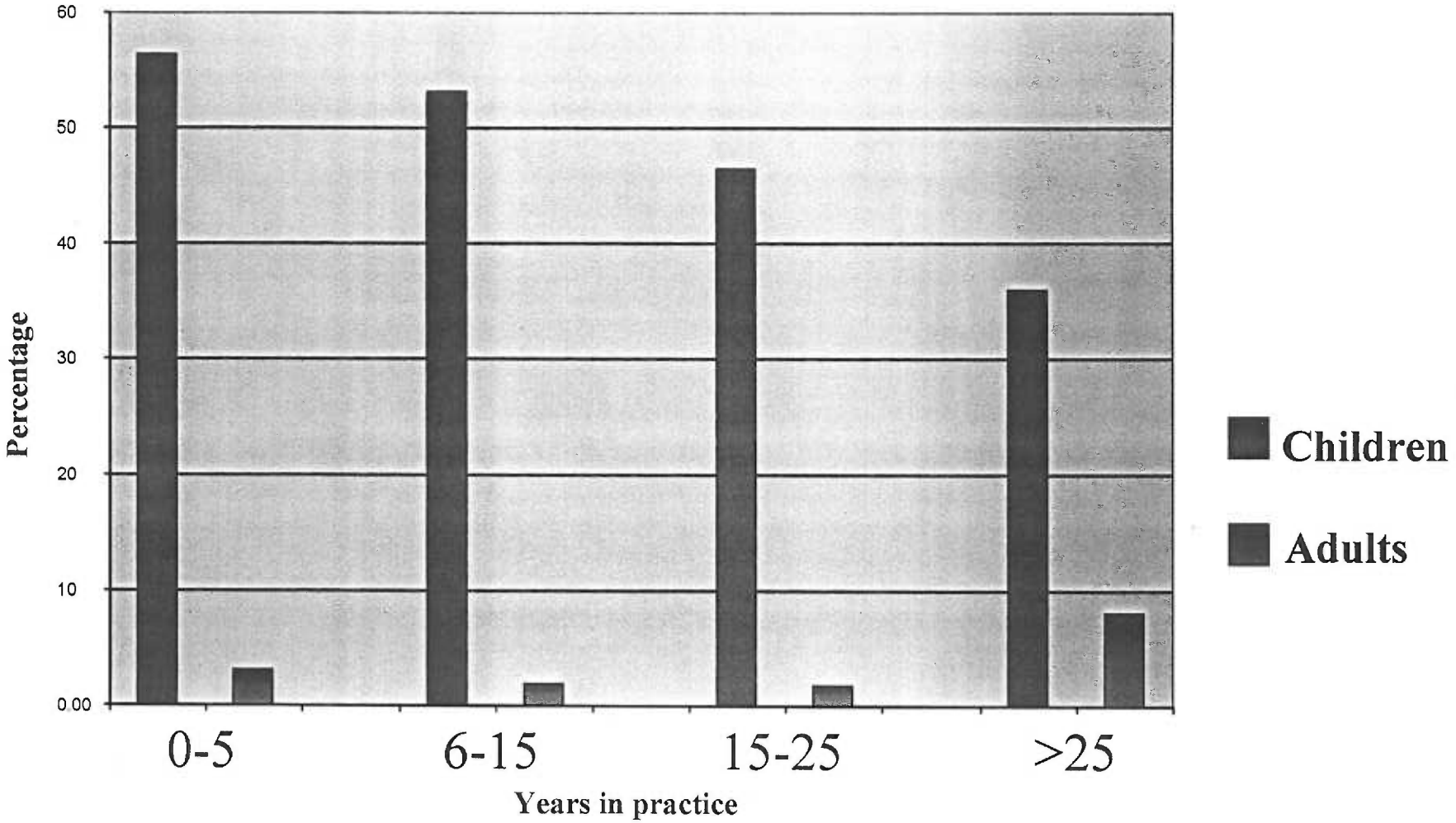

Chart 5 shows the percentage of practitioners who believe that it is possible to obtain growth beyond genetic potential.

CHART 6

Beyond Genetic Potential
Oregon vs. Washington

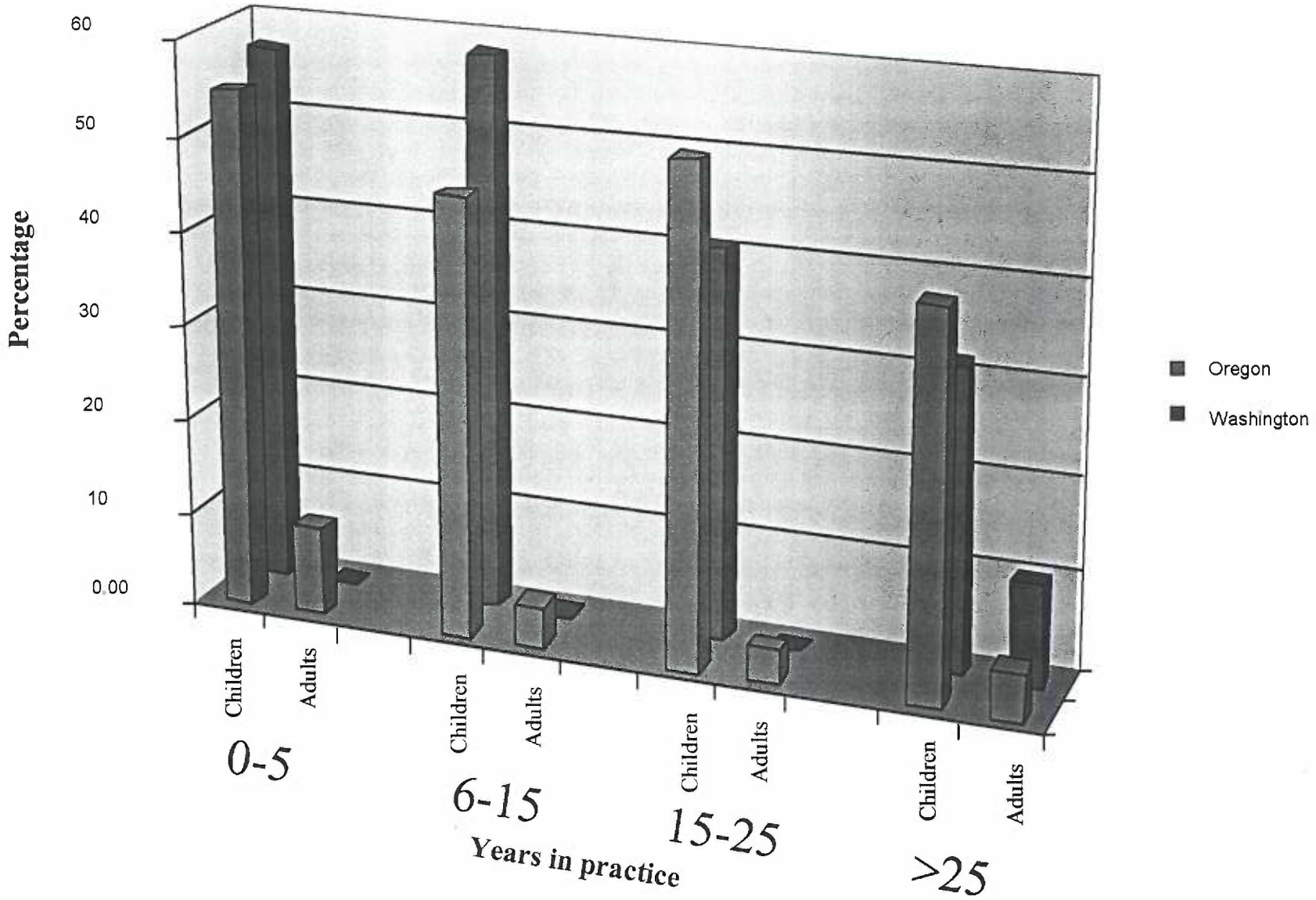

Chart 6 compares percentages of Oregon to Washington practitioners, who believe that it is possible to obtain growth beyond genetic potential. Blue bars represent orthodontists practicing in Oregon while red bars represent those practicing in Washington.

CHART 7

Airway Evaluation and Management

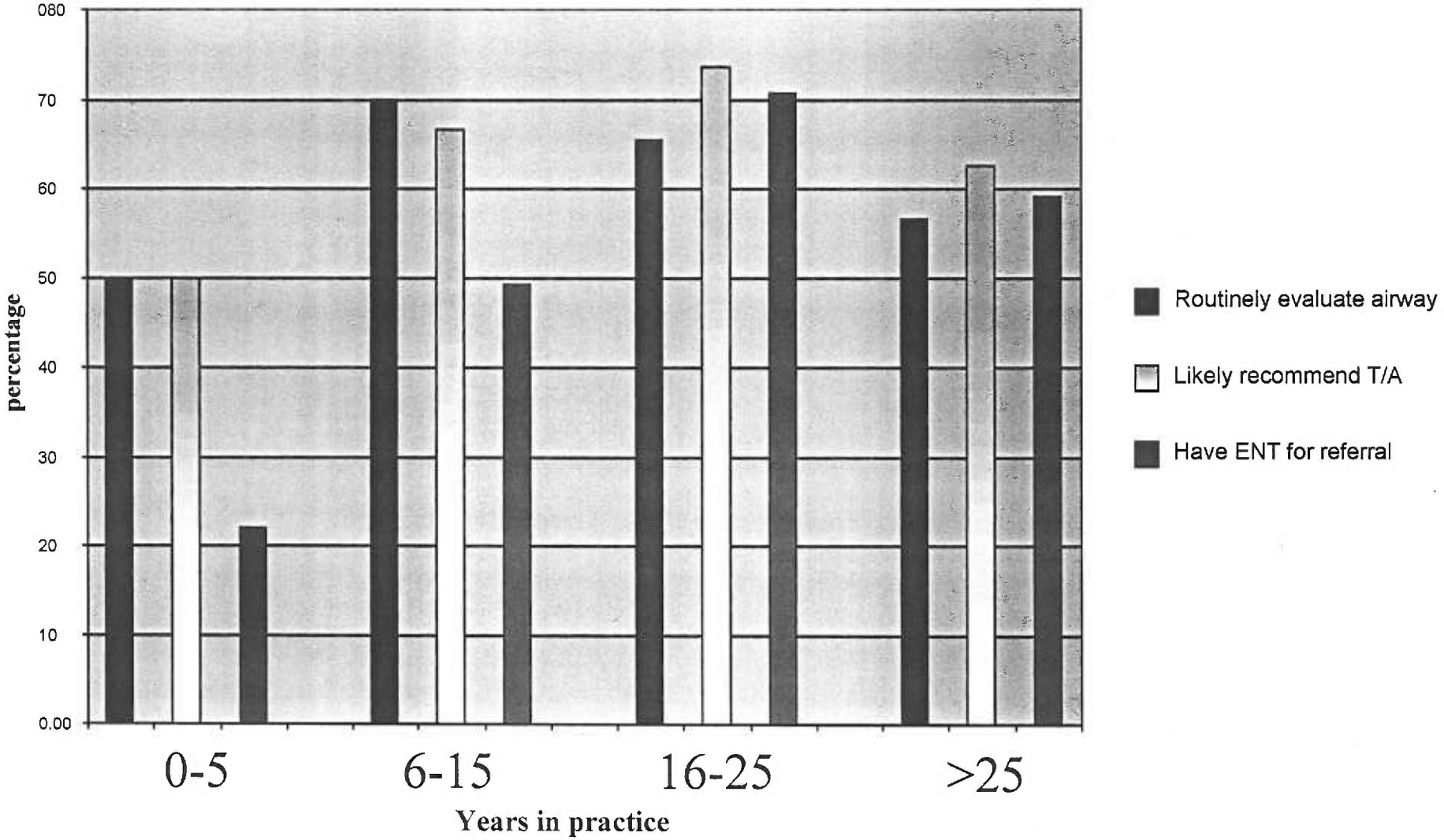

Chart 7 shows the percentage of practitioners who routinely evaluate airway, who recommend tonsillectomy and/or adenoidectomy, and have an ENT for referral.

CHART 8

Airway Evaluation and Management
Oregon vs. Washington

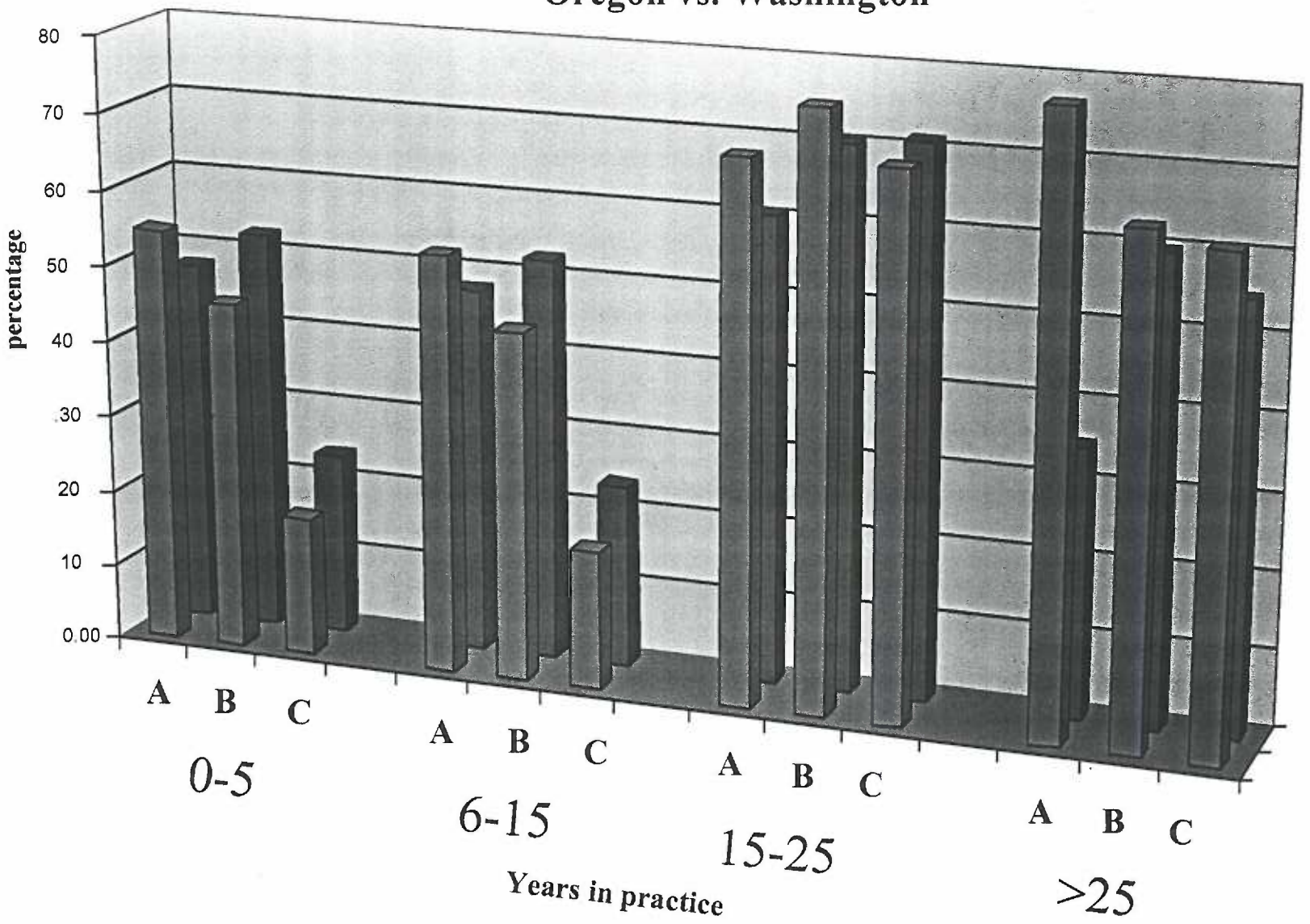

Chart 8 compares the percentages between Oregon and Washington practitioners who (**A**) routinely evaluate airway, (**B**) recommend tonsillectomy and/or adenoidectomy, and (**C**) have an ENT for referral. Blue bars represent orthodontists practicing in Oregon while red bars represent those practicing in Washington.