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THE EFFECTS OF ORTHOPEDIC FORCES—CASE REPORT

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The following patient (Fig. 1) is one of a test group of 14 children exhibiting Angles Class II division I malocclusions in which the effects of various orthopedic procedures on the craniofacial complex are being analysed. This group forms part of a larger study investigating the effect of gradients of extra-oral force.

The patient was subjected to rapid expansion of the maxilla (5.6 mm over 14 days) prior to the application of extra-oral force directly to the expansion appliance (Figs. 2 and 3). On the same day as the last activation of the screw, a headgear of the Armstrong design consisting of a headcap and neckstrap incorporating calibrated coil springs was fitted (Fig. 4). This was connected to the expansion appliance via a reinforced 0.05 inch face bow which inserted into .051 inch buccal tubes on the 6/6 bands. The buccal tubes were placed as far to the gingival as possible to minimise the distance between the headgear tube and the trifurcation of the roots of 6/6. The overall objective was to deliver a force at least within the range of that exerted by the Milwaukee brace (Logan, 1962) and to attempt to attain a force to body weight ratio as close as possible to that achieved in the animal experiments of Elder and Teunge, (1974); Thompson, (1974) and Droschl (1973). The magnitude and direction of extra-oral force vectors were assessed with the patient sitting erect, with Frankfort plane horizontal (Fig. 5). The maximum tolerable force for this patient was approximately 120 ounces and the frequency of headgear wear was 90-100 hours per week during this initial period of headgear wear. After 163 days headgear wear, clinical and cephalometric examination indicated a correction of the Class II buccal relationship to Class I (Fig. 6). The rapid expansion appliance was removed and treatment completed using the edgewise appliance (Fig. 7). During this final period of treatment (20.6 months) the headgear was worn 60-70 hours per week. However, the previous force magnitude and face bow adjustment were maintained.

In order that change due to these various treatment procedures could be quantified and treated statistically, lateral cephalometric radiographs taken at the end of each stage of treatment were analysed in the following manner. (Table 1).

Skeletal Change (Fig. 8)

A reference grid involving the cranial base line Basion-Nasion (Ba-Na) and a perpendicular drawn to it from point W, mid-point on the mid-sagittal contour of the cranial base between the images of the greater wings of the spheniod bone, was used. (Van der Linden and Enlow, 1971). The points Rhinon (R), Pronasale (Prn), Anterior Nasal Spine (ANS) and Pterygomaxillary Fissure (PTM) were recorded in terms of linear distances to these co-ordinates. The linear distance between ANS and the perpendicular from PTM to the palatal plane was also measured (Moore, 1959).

A line from point W was drawn tangent to the maximum superior curvature of the planum sphenoidale (Sphenoid Plane). The angle between this line and Basion-Nasion was used to study the behaviour of the body of the sphenoid bone. Change in this angle was correlated with linear changes in the perpendiculars from Basion and Nasion to the Sphenoid Plane. Other angles measured were the angles made by the Mandibular Plane (Gonion-Menton) and the Palatal Plane (Anterior Nasal Spine-Posterior Nasal Spine) with Basion-Nasion. The angle Basion-Nasion-A point (Ba-Na-A) was used to measure maxillary convexity.

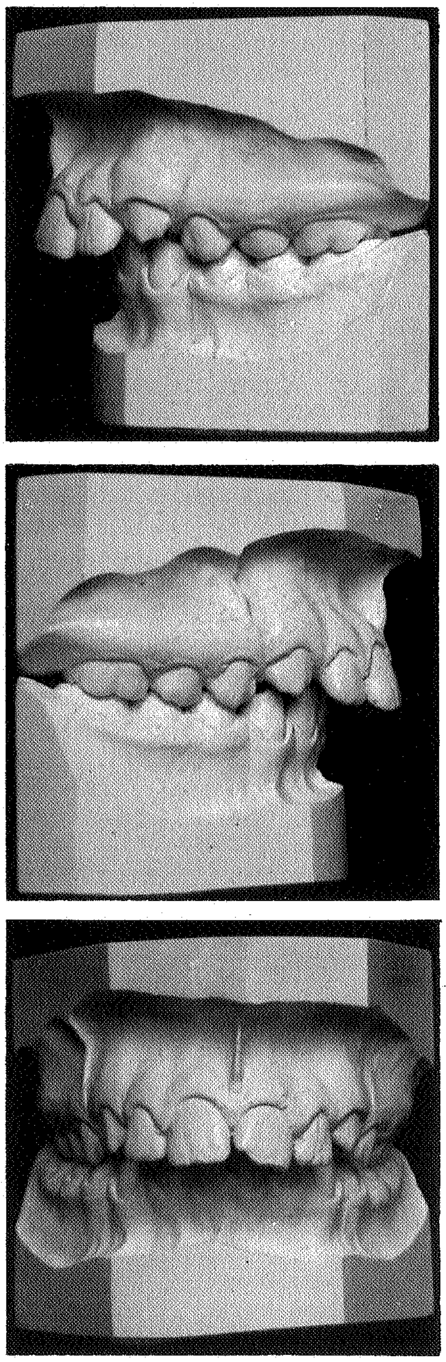

Fig. 1. Original study models of patient L.M. Chronological age was 122 months and skeletal age was 120 months.

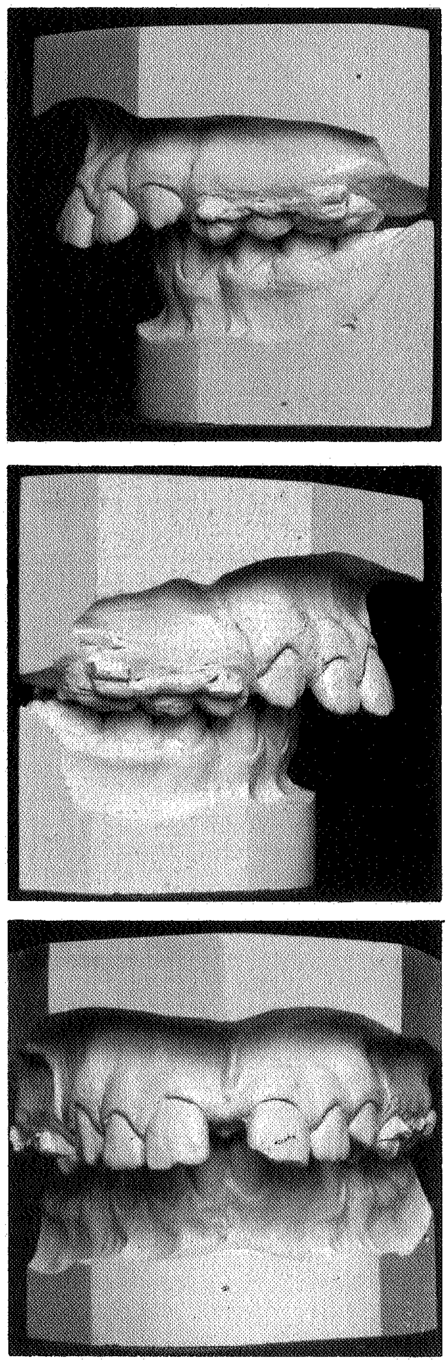

Fig. 2. Study models of patient L.M. after rapid maxillary expansion. Note the position of the buccal tubes on $\underline{6|6}$, the scissor bite of the buccal teeth and the diastema between the maxillary central incisors.

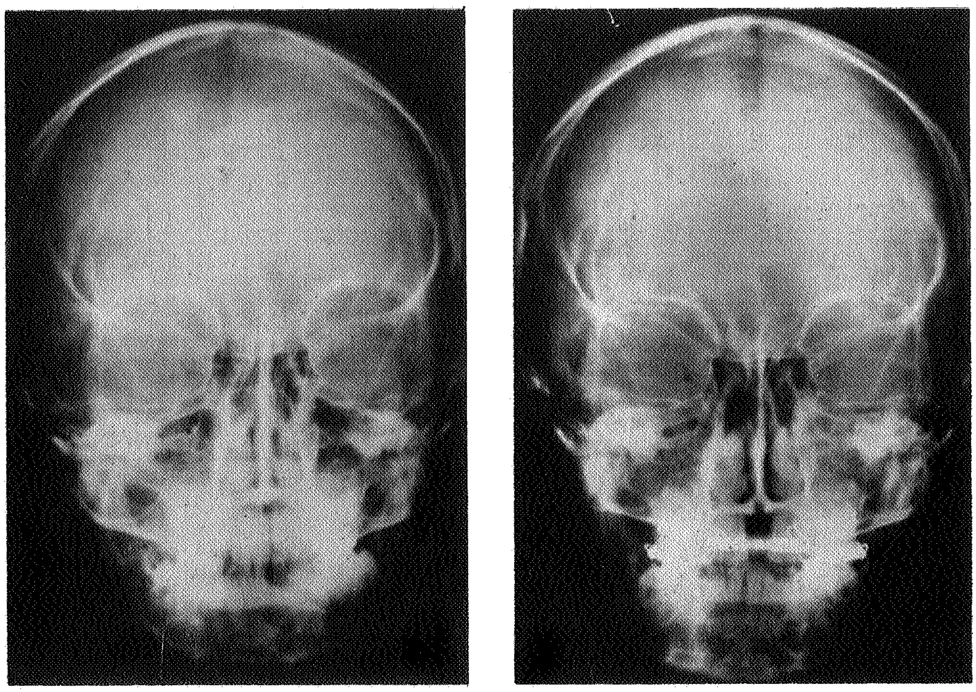

Fig. 3. Postero anterior cephalograms of patient L.M. before and after rapid maxillary expansion. Note the dysjunction of the vomero-maxillary articulation.

Fig. 4. Headgear activated and in situ. Note that flexion and extension of the head will have a more marked effect upon the force exerted by the neck-strap than the headcap. Any change in headcap force is due to the relatively small amount of vertical movement of the face bow.

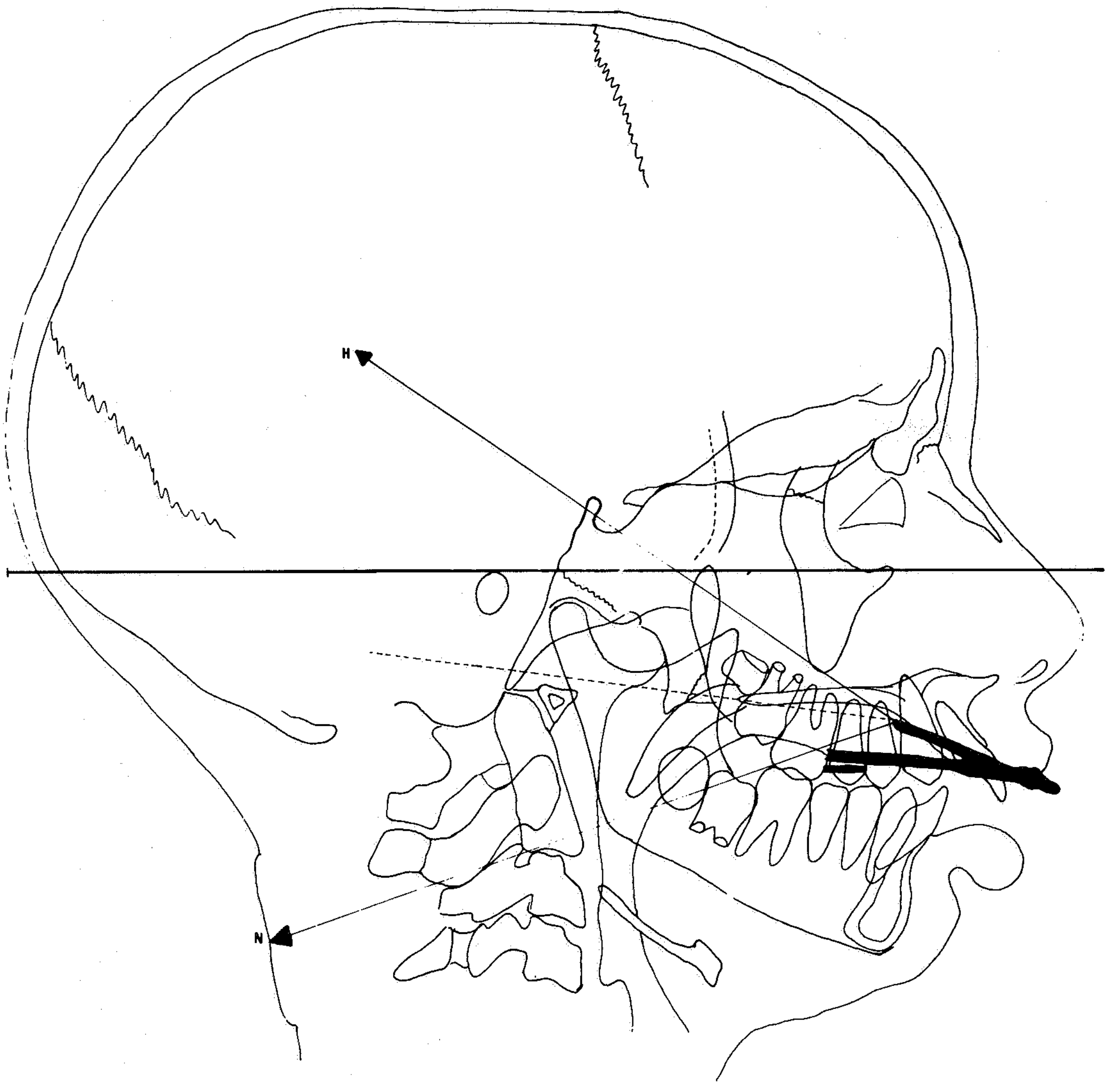

Fig. 5. Relationship of the headcap and neckstrap force vectors to the maxillary teeth, circum-maxillary suture system, and the atlanto occipital joint when Frankfort Plane is horizontal. The interrupted line represents the resultant force if the headcap and neckstrap forces are of equal magnitude. Flexion and extension of the head around the atlanto occipital joint will change the distance between N and the outer arm of the face bow resulting in changes in neckstrap force. In the position illustrated the centre of gravity of the skull lies in front of the atlanto occipital joint, the head being maintained in this position by the tonus of the extensor muscles, predominantly the semispinals capitis. Flexion of the head can be a result of relaxation of the extensors and/or activity of the longus capitis and sterno-mastoids.

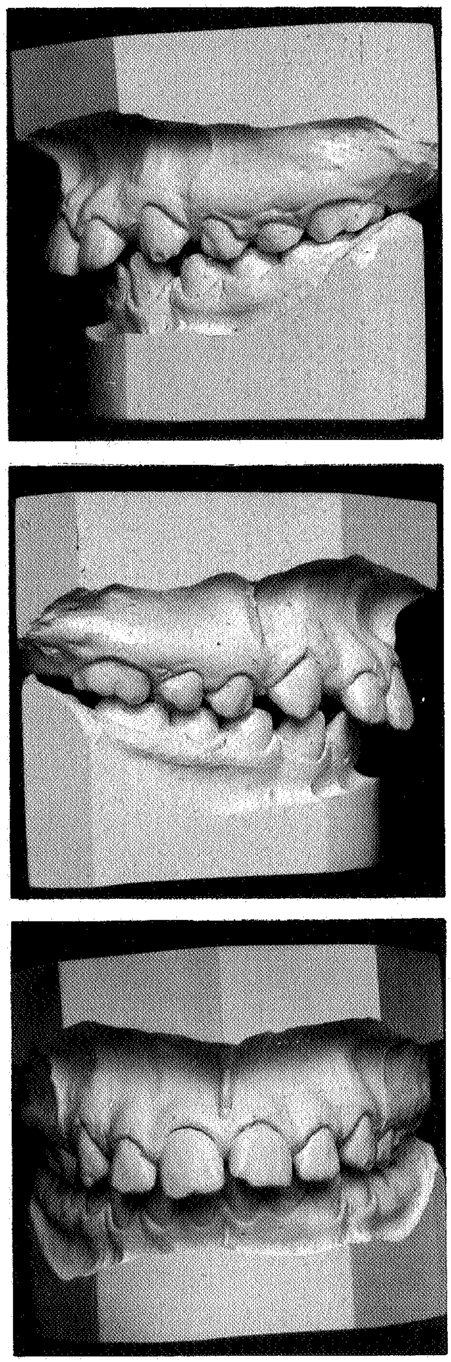

Fig. 6. Study models of patient L.M. after 163 days headgear wear. Note the reduction of overjet the correction of the buccal occlusion and closure of the diastema between the central incisors.

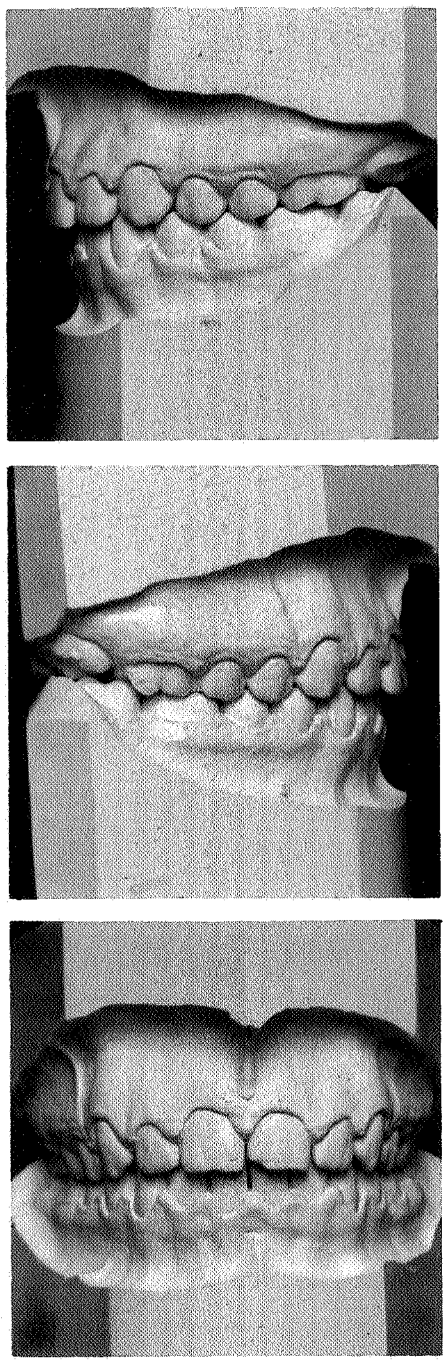

Fig. 7. Final study models of patient L.M. taken at the end of the period of conventional orthodontic treatment utilizing the edgewise appliance.

Table 1. Skeletal and dental changes measured on lateral cephalometric radiographs. Skeletal change is measured in terms of linear changes in relation to the reference grid and angular changes in relation to Ba-Na. Dental change is measured in terms of linear and angular changes in relation to the palatal plane and ANS.

Skeletal Change

Changes (mm or degrees in horizontal (⇄) or vertical (↑↓) direction	Rapid Expansion	Initial H.G.	Final H.G.
Ba-Na-A	1.0°	−1.0°	−6.0°
Ba-Na-R	1.0°	−0.5°	1.0°
Ba-Na-Prn	1.0°	−2.0°	1.5°
Sphenoid Plane −Ba-Na	0°	−0.5°	0°
Ba-Na-Palatal Plane	−0.5°	1.5°	4.0°
Ba-Na-Mandibular Plane	1.0°	−0.5°	2.0°
Point ANS ⇄	0.0	← 2.5	← 5.5
Point Prn ⇄	← 1.0	← 1.0	← 1.0
Point R ⇄	→ 1.0	← 5.0	→ 1.0
Point PTM ⇄	0.0	0.0	← 1.0
Point ANS ↑↓	↓1.0	↓0.5	↓1.5
Point R ↑↓	↓1.5	↓1.0	↓1.5
Point PTM ↑↓	↓0.5	↑2.5	↑2.5
Na-Sphenoid Plane	0.5	−1.0	0.0
P-Na	0.5	0.5	1.5
P-Ba	0.5	1.5	2.5
ANS-PTM	−0.5	−1.0	−3.0
Ba-Sphenoid Plane	1.5	2.0	3.5

Dental Change*

Changes (mm or degrees in horizontal (⇄) or vertical (↑↓) direction	Initial H.G.	Final H.G.
6 ⇄	← 2.0	→ 1.0
7 ⇄	← 4.5	← 0.5
6 ↑↓	↓1.0	↓4.0
7 ↑↓	↓1.5	↓7.5
6	1.0°	0.0°
7	2.5°	−11.0°

* Mesial tipping – negative values.

Table 2. Percentage change in facial height compared with pre-treatment measurements.

	Rapid Expansion	Initial H.G.	Final H.G.
Na-Me	2.2%	2.6%	5.7%
Na-ANS	3.8%	6.6%	9.4%
ANS-Me	3.0%	0.0%	3.0%

Table 3. Increase in arch width compared with original study model measurements (mm).

	$\underline{3/3}$	$\overline{3/3}$	$\underline{4/4}$	$\overline{4/4}$	$\underline{5/5}$	$\overline{5/5}$	$\underline{6/6}$	$\overline{6/6}$
Rapid Expansion	4.5	0.0	7.0	0.5	6.0	0.0	6.5	1.0
Initial Headgear	6.0	2.0	6.0	2.5	8.0	3.0	6.0	2.5

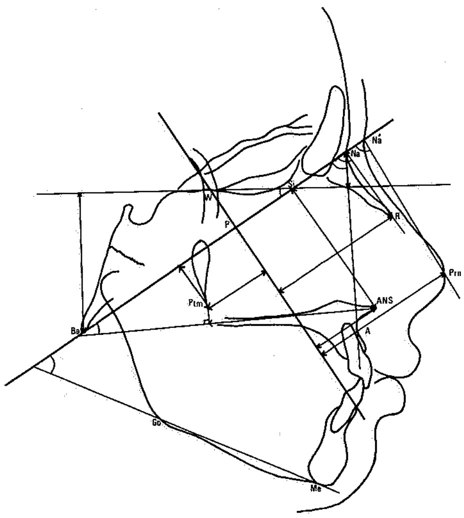

Fig. 8. Angular and linear measurements made in order to determine skeletal and soft tissue change.

Dental Change (Fig. 9)

Templates representing the maxillary central incisor, first premolar, first, second and third molars were constructed from the last tracing in the series. Angular and vertical changes of these teeth were related to the palatal plane. Horizontal change was related to the anterior nasal spine.

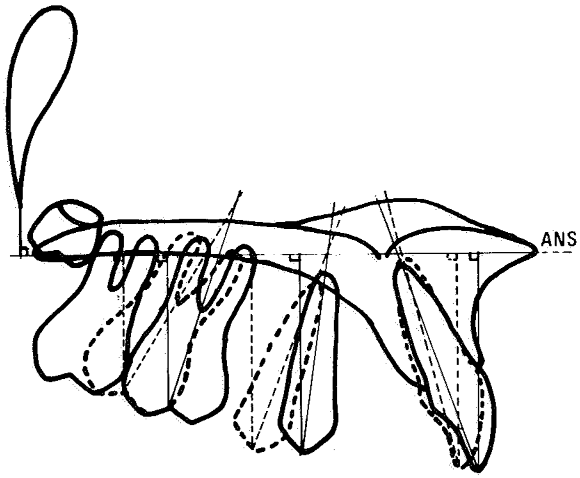

Fig. 9. Angular and linear measurements made in order to determine dental change in relation to the palatal plane and ANS.

Analysis of Study Models (Table 3)

The intercanine, interpremolar, and intermolar widths were recorded at the end of rapid expansion and after the initial application of headgear. Intercanine and interpremolar widths were measured between the tips of the buccal cusps and intermolar width between the occluso-buccal junctions of the buccal fissures.

All members of the test group subjected to this experimental procedure demonstrated varying amounts of expansion of the lower molar and premolar width and proclination of the lower incisors after the initial period of headgear wear. In the case of patient L.M. the spontaneous change in the lower arch was marked and demonstrates these side effects well. (Fig. 10)

Fig. 10. Occlusal view of the lower study models of patient L.M. The left study model is the original, the middle study model is immediately after the initial period of headgear wear (163 days) and the right study model the final model taken at the end of treatment. Note the increase in intercuspid, interpremolar and intermolar width and proclination of the lower incisors on the middle model. The final model illustrates the change in arch form resulting from retraction of the lower incisors, contraction of the cuspid width to its original dimension and maintenance of the bicuspid width at the dimension seen in the middle model.

Spontaneous decrowding and expansion of the lower arch during the correction of Class II buccal occlusion with headgear has been reported before (Brodie, 1971; Ricketts, 1973, 1975) and attributed to subtle changes in occlusal relationship. It is probable that the expanded upper arch and the resulting reduction in tongue space due to the presence of the rapid expansion appliance also contributed to the lower arch response in these cases. Another factor which is illustrated in this case is the effect of the head position frequently adopted by children wearing this extra-oral force system, particularly when neckstrap force values are high. From Fig. 5 which represents the force system activated and in equilibrium, it is apparent that the neckstrap force vector passed well below the atlanto-occipital joint, through the articulation of C_2 and C_3. As the force exerted by the neckstrap was approximately 3.5 pounds it can be appreciated that there was a considerable clockwise moment around the atlanto-occipital joint. The use of the headcap in conjunction with the neckstrap not only allowed a greater distal component of force to be applied to the maxillary teeth, but also allowed an extremely large neckstrap force to be applied by counteracting the painful extrusive force vector exerted by the neckstrap on the maxillary teeth. (Armstrong, 1971).

Although patients were radiographed in the cephalometer with Frankfort Plane horizontal, this was by no means the postural position adopted by patients during a normal period of headgear wear. Many parents commented that the children soon adopted a position where the head was canted forward in a "chin in chest position". This was apparent when they were ambulatory and particularly so when they were asleep, and was associated with a forward posture of the tongue and mandible which was seen as a compensatory reaction in order to preserve the oro-pharyngeal space for respiration.

In the case of patient L.M. the change in tongue position was seen as an important factor in the lower arch response during the initial period of headgear wear. As in all cases, the forward canting of the head was interpreted initially as an attempt to lessen the neckstrap force vector by flexure of the cervical vertebrae and adduction at the atlanto-occipital joint. Although this may have been a voluntary response initially it was probably an involuntary response when the post-cervical musculature tired or the patient was asleep.

As a result of this interpretation some of the lower arch dimensions after the initial period of headgear wear were regarded as unstable, resulting from a temporary environmental change due to the treatment procedures. Consequently the canine expansion and incisor proclination were reduced during the final period of treatment (Fig. 10).

Summary

Traditionally, extra-oral force vectors have been related to the teeth and circum-maxillary suture system (Merrifield and Cross, 1970; Armstrong, 1971; Worms et al, 1973). The case described illustrates another factor one must be cognizant of when heavy extra-oral force is applied by a headgear utilizing a headcap and neckstrap attached to a facebow with shortened outer arms.

Cephalometric Points and Planes

Rhinon (R): The most anterior inferior point on the tips of the nasal bones as seen from norma lateralis.

Pronasale (Prn): The most anterior point on the midsagittal profile of the nose.

Soft Tissue Nasion (Na'): The point of intersection of the soft tissue profile with a line extended from the line Basion-Nasion.

Sphenoid Intersection (Si): The intersection ofthe Sphenoid Plane and the line Basion-Nasion.

Point W: The midpoint on the midsagittal contour of the cranial base between the images of the greater wings of the sphenoid bone.

Point P: The intersection of the perpendicular from Point W on Ba-Na.

Pterygomaxillary Fissure PTM: The inferior intersection of the images of the anterior and posterior walls of the pterygomaxillary fissure.

Sphenoid Plane: The plane drawn from Point W tangent to the maximum superior curvature of the planum sphenoidale.

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