An Analysis of Midline and Offcenter Extraoral Force

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A division of opinion has been evidenced regarding the efficacy of unilateral or offcenter headgear to act any differently from the more widely used bilateral or midline headgear since the cervical strap, elastics and relatively rigid facebow-labial arch roughly form a closed or circular system which dissipates force applied at any one point around the entire system.

The purposes of this study were (1) to compare and analyze the relative distribution of force afforded by two types of offcenter extraoral appliances with each other and with that of a midline appliance when elastic traction was bilaterally equal; and (2) to determine and analyze the resultant manner in which uneven elastic traction acted on a midline appliance.

METHOD

The recording of relative linear measurement of the elastic pull required to counterbalance elastic traction applied to each of three types of extraoral headgear placed on a symmetrical base.

The use of scales and wire springs was discarded as none could be constructed or obtained that could record finely enough or consistently the forces involved. Even with orthodontic elastics repeated tests indicated linear differences up to four millimeters; therefore no linear differential was considered significant unless it was greater than four millimeters. In addition, friction, individual elastic variation and some distortion of labial arch form precluded basing conclusions on differences of only a few millimeters.

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ANALYSIS

By the application of the mechanical laws of static bodies, of the moments around the stop-ends of the labial arches employed.

MATERIALS

Three .045 inch steel labial arches were adapted to conform to one symmetrical graph paper pattern. Each arch had a hook-stop soldered 13 millimeters from right and left distal ends.

Three facebows were adapted and soldered to the labial arches, the hook-ends of the facebows being, in each case, on the same horizontal plane with each other and equidistant from symmetrical points on either side of their respective labial arches.

In figure 1 the upper outline is that of the most commonly used bilateral or midline facebow-arch, the center outline is that of a conventional unilateral or offcenter facebow-arch and the lower outline, also an offcenter facebow-arch, is of a design suggested by Dr. J. Williams Adams of Indianapolis, Indiana. Two unequal facebow sections were joined and their stem was attached linearly to one side of the labial arch. Note that the place of attachment of facebow to labial arch is at a greater distance from the midline than in the conventional design shown although the place of attachment can be altered in either case.

A base (Fig. 2) consisting of: a) A metal rectangle 6½ by 7½ inches divided by a line through the center. To one end was attached a wooden backboard in which were inserted two upright posts, 4½ inches apart and equidistant from the midline.

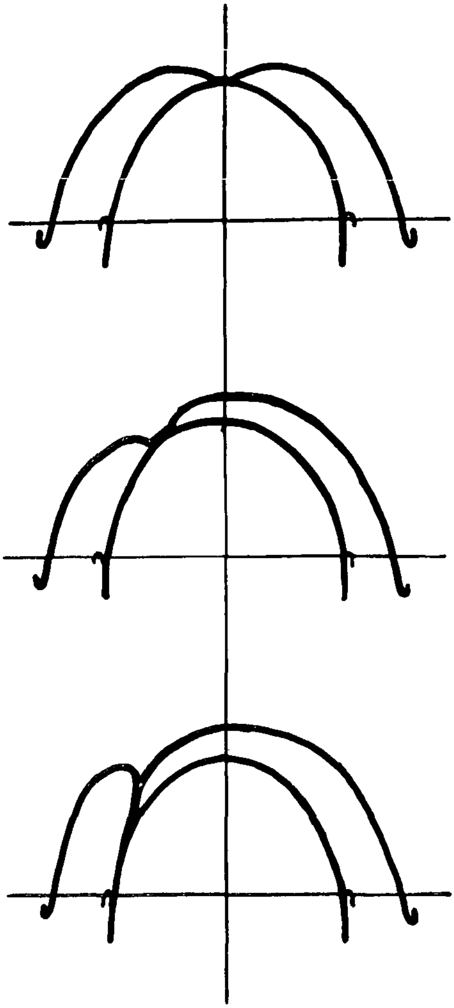


Fig. 1. Types of face bow.

b) Two .030 inch steel loops inserted in a wooden block attached to the metal base, lying two inches in front of and parallel to the backboard, equidistant from the midline by an amount equivalent to the width between the hook-stops on the facebow, 2⅜ inches.

c) Two jackscrews, each 52 millimeters long, attached to the metal base, perpendicular to the backboard and parallel to each other and lying 3½ inches in front of the loops. They were 1½ inches apart and to each end facing the backboard was attached a hook.

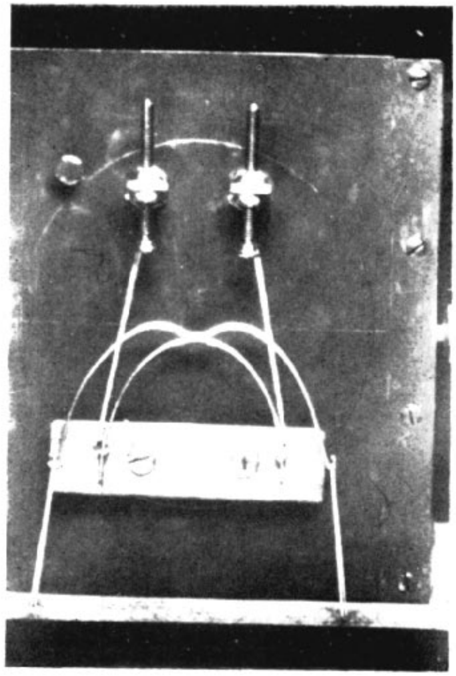


Fig. 2. Base.

Thumb screws propelled the jackscrews backward and forward from their points of fixation to the metal base. The labial arch ends were passed through the loops on the wooden blocks. One Unitek Latex elastic #301 was attached from each facebow hook to the corresponding upright post in the backboard and from each labial arch hook-stop to the corresponding jackscrew hook. The jackscrews were then withdrawn so that sufficient tension was produced in all four elastics to pull the labial arch forward. The jackscrews were then slowly extended until the labial arch pulled back. This technique was used to overcome initial friction and play in the machine. When the hook-stops reached the same baseline on the wooden block containing the loops through which the labial arch ends passed, caliper measurements were taken of the length of each jackscrew extending from its respective thumbscrew (Fig. 3). These measurements represented the relative

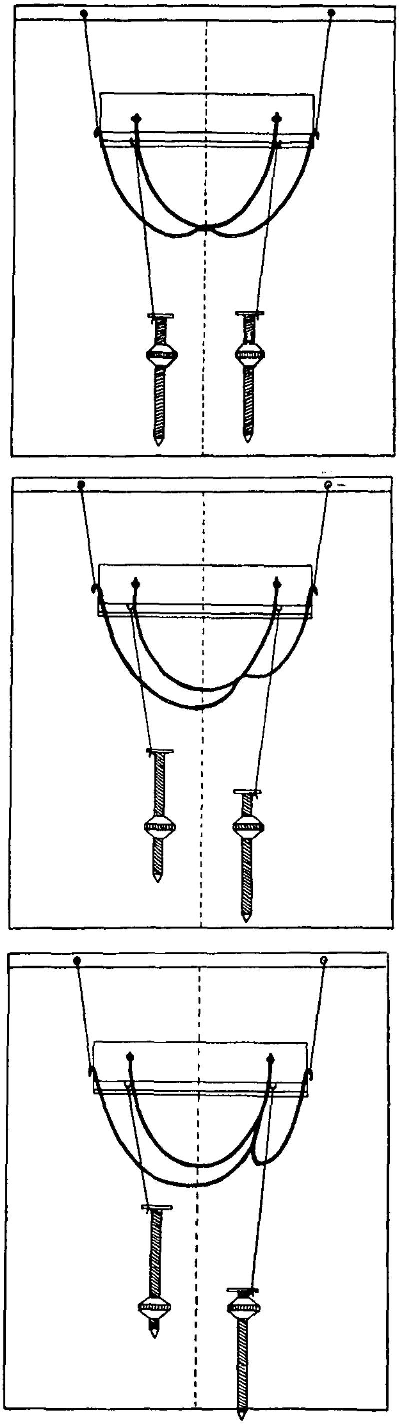


Fig. 3. Jackscrew extension.

amount of elastic pull required to neutralize the resultant force at the hook-stops transmitted through the labial arch, which force was created by the equal length and therefore equal tension of the similar elastics extended from the facebow hooks to the upright posts in the backboard.

Findings

The diagrams and relative measurements presented are composites of a series of twenty trials for each type in which each appliance was reversed from right to left side after ten trials. Bilateral or midline appliance (Fig. 3 top) yielded a jackscrew extension measurement of 11 millimeters on the left side and 12 millimeters on the right side.

The conventional unilateral or off-center type (Fig. 3 middle) yielded a jackscrew extension of 27 millimeters on the left side and 9.5 millimeters on the offset or right side. More pull was required to counterbalance the offset side.

The unilateral or offcenter type as suggested by Adams (Fig. 3 bottom) yielded a jackscrew measurement of 36.5 millimeters on the left side and 3 millimeters on the offset or right side. A greater imbalance between right and left sides was evidenced here than in the conventional offcenter type.

The same trial was repeated with the midline or bilateral facebow-labial arch using two elastics on one side from facebow to backboard post (Fig. 4). The side to which double elastics were attached required greater force to be displaced at the hook-stop than did the opposite side. The jackscrew extension measurement on the left, or double elastic, side was 2 milimeters and that on the right side was 20.5 millimeters.

Analysis of the Findings

A force analysis of the findings just presented was derived from the application of two physical laws of static

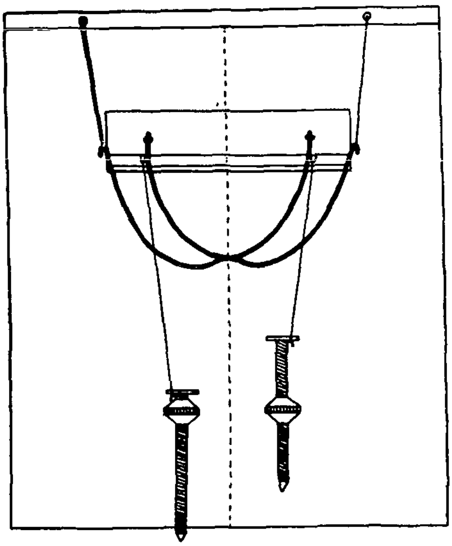


Fig. 4. Two elastics left, one right.

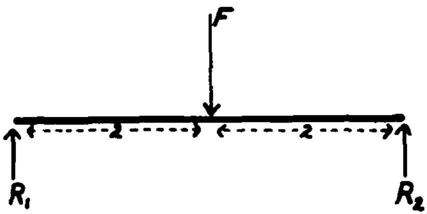
bodies, namely: (1) the sum of the forces of any body in equilibrium equals zero; (2) the sum of the moments of any body in equilibrium equals zero; By moment is meant the resultant of a force times the lever arm about any point under consideration. When this is applied to any beam, simply supported at its ends by two equal forces we have the following (Fig. 5).

R represents applied force which, in this case, is the rubber band applied. F represents the resultant force. The numbers are merely arbitrary linear units which simplify the equations. In a summation of moments equation clockwise moments are given plus values and counterclockwise moments receive minus values.

When the moments taken about the points on a simple beam are applied to a midline or bilateral facebow-labial arch, a symmetrical force arrangement, in balance, can be demonstrated (Fig. 6 top).

Therefore, if elastics on each side are equal, force exerted by the tooth against the hookstop at T_1 and T_2 are equal. Since reactions are equal and opposite, the resultants produced at the labial arch hookstops are equal.

When double elastics are applied from facebow hook to backboard post on one side the changes are considerable (Fig. 6 center). Note that the total applied force, 3R, is greater than the 2R with single elastics on either side since an additional elastic is being used. Thus, if double elastics are placed at R_1 and the single elastic remains at R_2 with the particular arbitrary linear units used, the resultant force at T_1 would be 9/4 or 2¼ times the loading at T_1 and ¾ the loading at T_2, as compared with the previously shown completely symmetrical force arrangement. Note that T_2 is now relatively less than it was before. This indicates a rotational effect about the midline. Clinically, this rotational effect is partly dissipated, it is believed, by friction along



$$R_1 + R_2 = F$$

Sum of moments about R_1:

$$\Sigma M_{R_1} = 0$$

$$\Sigma M_{R_1} = R_1 \cdot 0 + 2F - 4R_2 = 0$$

$$2F = 4R_2$$

$$R_2 = \frac{2F}{4}$$

$$R_2 = \frac{F}{2}$$

since $R_1 + R_2 = F$

$$R_1 + \frac{F}{2} = F$$

$$R_1 = F - \frac{F}{2}$$

$$\therefore R_1 = \frac{F}{2}$$

Fig. 5.

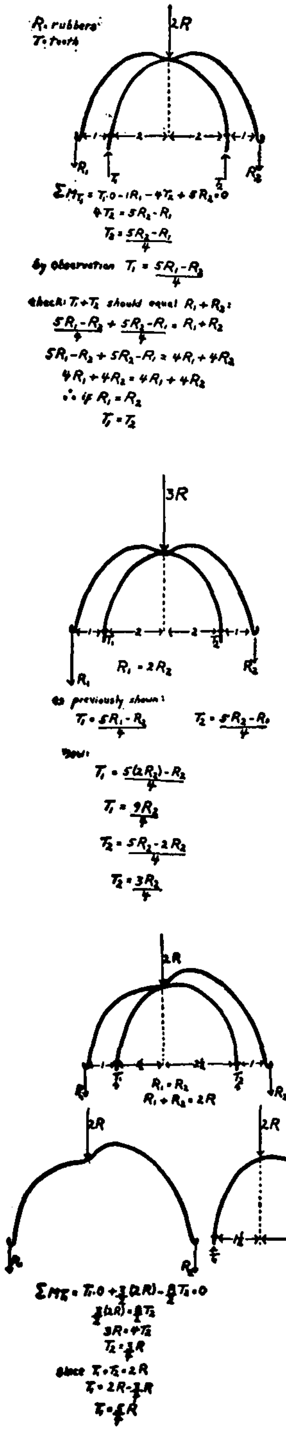


Fig. 6.

the length of the buccal tube. Compensatory bends in the labial arch may, to some extent, control rotation.

When a summation of moments diagram is made for the conventional offcenter appliance we use a free-body rather than a fixed or entire body analysis as was done with the symmetrical midline design (Fig. 6 bottom). Mechanics tells us that symmetry imposes the same conditions to external forces on the components as if they were joined in a solid unit. The advantage of treating the offcenter appliance as a free body is that its lack of symmetry would necessitate an analysis of the stresses inherent in the materials which would not affect the resultant mechanics. If the offcenter design were analyzed as a fixed body or welded truss, each joint would have to be taken as a free body.

With the Adam's suggested design the analysis is the same but the distances of T_1 and T_2 from the midline have shifted with a respective shifting of 2R from the midline, therefore T_1 becomes larger and T_2 smaller.

Summary

1) A non-clinical demonstration displayed relative force resultants produced by three types of cervical headgear; one midline and two offcenter. Force distribution was equal on both sides with the midline gear. The conventional offcenter design demonstrated resultant differentials; the greater resultant being produced on that side corresponding to the offcenter attachment of the facebow to the labial arch. The Adam's suggested offcenter type produced similar distribution but in relatively greater intensity than did the conventional offcenter type.

2) Unilateral double elastic traction was applied from facebow hook to backboard post with the midline or bilateral appliance producing a greater resultant on the double elastic side.

3) Analysis of the mechanics involved in each set-up was presented.

Conclusions

1) Unilateral or offcenter facebow attachments can produce resultant force differentials at the point of contact of a stop on a labial arch with the tube through which the end of the arch passes.

2) The greater resultant is on the side of the offset.

3) The relative offset differential increases directly as does the distance of the attachment from the perpendicular midline through the labial arch.

4) The application of double elastics on one side from facebow to cervical portion of the headgear can produce a resultant force differential at the point of contact of labial arch stop with the tube through which the end of the arch passes. The greater resultant is on the double elastic side.

Discussion

Regardless of the actual configuration of the facebow, the resultant produced at the tooth is dependent on the point of application, the magnitude and direction of the applied force if the labial arch is symmetrical and the hook-ends of the facebow lie on the same horizontal plane and are equidistant from corresponding points on either side of the arch. Although extraoral headgear is depicted as a closed or continuous circuit and the application of force at any point on the system as being transmitted throughout, the following features should be noted (Fig. 7).

1) Friction along the contact of the cervical strap with the back of the neck prevents transmission of pull around the circuit. In fact, it is this very friction which, in part, enables the appliance to act as it does.

2) The points of contact between the stops on the labial arch and the buccal tubes in themselves act as fulcra about which the applied force is dissipated, either in a straight line along the buccal tube or as a distal rotation. Therefore, when the point of attachment of facebow to labial arch is offcenter the buccal tubes are not the recipients of equal force.

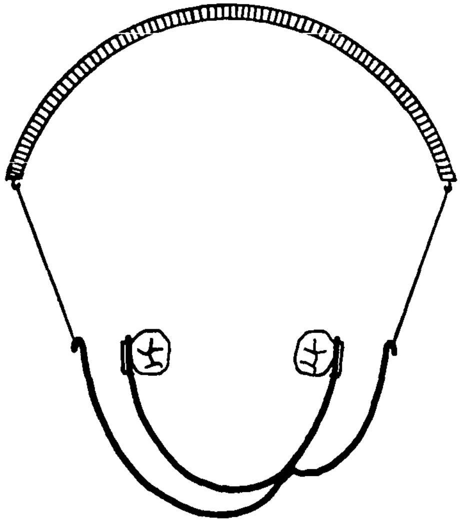


Fig.7. Extraoral headgear.

3) The results produced by unilateral double elastics extended from facebow to cervical strap in no way upset the closed system concept, they confirm the contention that friction stabilizes a portion of the appliance so that the continuity is, at least partially, interrupted.

Substitution of a movable cervical strap for the rigid backboard would have more closely resembled clinical actuality but was not applicable here for the following reasons; the main consideration was to measure force inherent in the facebow-labial arch and this could not have been accomplished as accurately if the ultimate point of attachment of the elastics had not been rigid; although, clinically, there is some play and movement between cervical strap and the back of the neck, the range and amount are inconstant variables and, as already mentioned, the efficiency of the machine is, in part, dependent on the degree of fixation, due to friction, of cervical strap to neck.

Under clinical conditions certain factors can act to modify the non clinical results demonstrated causing a midline appliance to act in an offcenter manner and vice versa. Among these are: mandibular displacement which, if diagnosed, may contraindicate the use of unilateral headgear; occlusion itself; pillowing habits; sleeping on one side only; unusual neck contour; improper placement of gear by patient so that the tension in the elastics is unequal; and distortion and loss of symmetry of the labial arch and facebow.

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