Unilateral Cervical Traction With A Kloehn Extraoral Mechanism

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There exists a lack of understanding regarding the production of unilateral cervical traction with a Kloehn extraoral mechanism. The present method of offsetting the joint between the extraoral and oral bows is not theoretically correct unless the joint is a knife-edge. In the following material two steps are presented which can be utilized to achieve unilateral action. These steps do not involve changes in the location of the joint between the two bows. Instead, the aim is to alter the positions of the lines of action of the applied forces so that the line of action of the resultant lies closer to the molar against which greater force action is desired.

Figure 1 represents a plan view of a Kloehn mechanism. Points *m* and *n* of the oral bow are inserted into buccal tubes attached to the upper first molars. Points *j* and *k* serve as attachments for an elastic cervical strap which supplies the force for tooth movement. The arrows are vectors which signify the magnitudes and directions of the applied forces acting in the plane of the mechanism. The T vectors represent the pull of the cervical strap and, since this strap is continuous, the forces at *j* and *k* are equal in magnitude. Vectors F_L and F_R represent the reactive forces exerted by the buccal tubes against the oral bow. Since action and reaction are equal, the oral bow exerts F_L and F_R against the buccal tubes and through these against the molars. If the molars are tied to the other teeth of the maxillary arch, the entire arch is, of course, subjected to F_L and F_R.

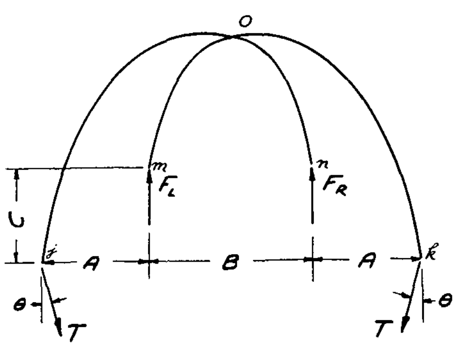

Fig. 1, Plan view of a Kloehn extraoral mechanism. Points *m* and *n* enter buccal tubes. A cervical elastic strap is attached to points *j* and *k*.

To illustrate the system of forces active in cervical traction, it becomes necessary to write general mathematical expressions of the physical conditions which must be satisfied to produce static equilibrium of the appliance. One of these physical conditions is that the sum of the forces parallel to F_L and F_R must be zero. This is just another way of stating that the forces must be in balance. Thus from Figure 1:

1. $F_L + F_R - 2T \cos \Theta = 0$

A second physical condition to be met is that the sum of the moments of the forces about any point in the plane of the forces must be zero. It may be remembered that a moment of a force is the product of the magnitude of the force and the perpendicular distance from a given point to the line of action of the force. In symbols, taking moments about point m:

2. $F_R \times B + T \cos \Theta \times A + T \sin \Theta \times C$
$- T \cos \Theta \times (A + B) - T \sin \Theta \times C = O$

When these equations are solved simultaneously for the two unknown quantities, F_L and F_R, it will be found that $F_L = F_R$. This result is in keeping with the common experience that a symmetrical system of forces produces uniform force action against the buccal tubes. It may seem unnecessary to utilize equations 1 and 2 to arrive at this simple conclusion; however, these equations are important because they show which physical quantities affect the action of the appliance.

A mathematical background is not needed to recognize the quantities in equations 1 and 2. Forces T, F_L and F_R are present as are dimensions A, B and C. Also of importance is the direction of T with respect to the sagittal plane (forces F_L and F_R are assumed to be parallel to the sagittal plane). The location of the joint at O, on the other hand, does not enter into either equation. This joint is invariably soldered, welded, or banded and it must be considered as being rigid. Even when this joint consists of a pin and tube, it resists bending in the plane of the appliance. Since this joint is rigid, it does not represent a point where external forces are applied. In other words the extraoral and oral bows comprise a single unit and the location of the union between them has no significance as far as external force action is concerned. It is well known in mechanics that the external effects of a force on a body are not influenced by the shape of the body. In any force system attention must be focused on the magnitudes of the forces, on the positions of the lines of action of the forces and on the directions of the forces along their respective lines of action. The performance of any appliance is governed by these characteristics and not by appliance configurations as such.

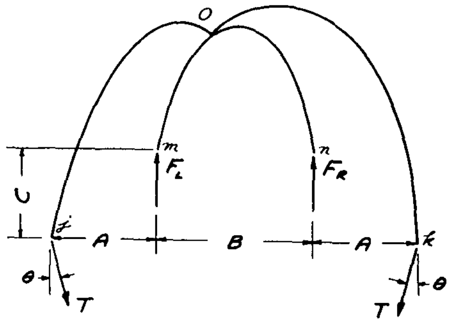

Fig. 2, The joint at O between the oral and extraoral bows has been offset to the left from its central position shown in Fig. 1.

As an example of the above principles reference is made to Figure 2. Here the shape of the appliance has been changed by offsetting the joint to the left of its original central position. This is the technique commonly used with the intention of increasing the load against one buccal tube while decreasing the load against the other. In short, unilateral action is supposed to be established. Inspection of Fig. 2, however, will reveal that this procedure has not altered any of the lines of action, directions or magnitudes of the applied forces. Equilibrium equations for this appliance would be exactly as before with the result that F_L and F_R must be equal. Thus, offsetting the soldered joint is not the road to unilateral action because this does not change the relationship between the applied and the reactive forces. An offset would work if the rigid joint were replaced by a knife-edge type of connection so that no torque or bending moment could be transmitted through O. In that case O becomes a point at which an external force is applied. Obviously, it would be impossible to utilize a knife-edge connection between the extraoral and oral bows in clinical orthodontics.

The above principles suggest a method by which the reactions F_L and F_R could be made unequal. For example, if it is desired to subject the right buccal tube to a greater force than the left, some way must be found to bring the line of action of the resultant of the T forces closer to the right than to the left tube. The resultant of the T forces is the single force having the same external effect as the two T forces.

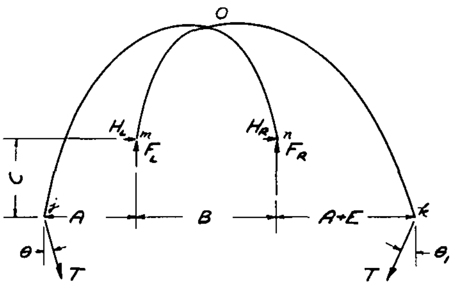

Fig. 3, Point *k* has been displaced laterally to the right an amount E. The angles between the cervical strap and the sagittal plane are no longer equal on both sides.

To displace the line of action of the resultant to the right, it is necessary to displace the lines of action of the T forces to the right. Because of physical limitations it is not possible to displace *j* to the right, but it is feasible to do so with *k*. This has been done in Figure 3 where *k* has been moved laterally to the right an amount E. The solution of appropriate equilibrium equations will show that this step will increase F_R by an amount approximately proportional to $T \times \frac{E}{B}$ and decrease F_L by a similar amount. If E could be made large enough, total unilateral action could be realized by this step alone. Unfortunately, it is seldom possible to increase E beyond a value of about three fourths of an inch because of the likelihood that the appliance

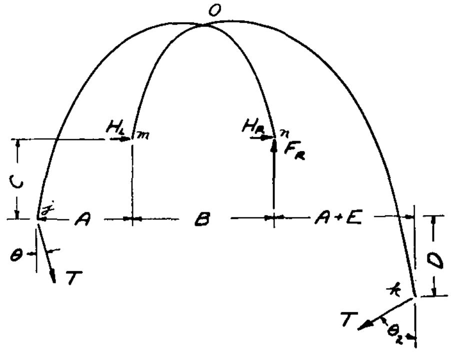

Fig. 4, The right arm of the mechanism has been lengthened an amount D relative to the left arm. Point *k* is displaced to the right an amount E.

will be dislodged during sleep. This limitation requires the introduction of a second step, first used at the University of Nebraska,[1] which is shown in Figure 4. Here the right arm of the face bow has been lengthened by an amount D. Such lengthening has the effect of rotating the resultant clockwise thereby bringing its line of action even closer to the right buccal tube. Equilibrium equations based on Figure 4 give the following:

$$3.\ F_R = \frac{T \cos \Theta_2 \times (B + A + E)}{B} + \frac{T \sin \Theta_2 \times (C + D)}{B} - \frac{T \cos \Theta \times A}{B} - \frac{T \sin \Theta \times C}{B}$$

$$4.\ F_L = T (\cos \Theta + \cos \Theta_2) - F_R$$

Now, if numerical values are substituted for A, B, C, D, E, T and Θ, the magnitudes of F_L and F_R can be calculated. Averages of a large number of measurements based on appliances in use can be used for typical values of the above quantities. With the inch as a unit of length and letting A = 1⅜, B = 2¼, C = ¼, D = 1¾, E = ¾, Θ = zero degrees, Θ_2 = 48 degrees, and T = 1 pound, it will be found that F_R equals approximately 1.4 lbs. and F_L equals about 0.3 lbs.

Thus, under these conditions the right buccal tube receives more than four and one half times the load received by the left buccal tube. Further increases in D and E would continue to increase F_R and decrease F_L. Finally a point will be reached where F_R represents all of the distally directed force. In fact, if D and E are made too large, the appliance will be pulled out of the left buccal tube since the left reaction must become negative. In this case the line of action of the resultant lies to the right of the right buccal tube.

If Figures 3 and 4 are re-examined, lateral forces H_L and H_R will be observed which do not appear in Figures 1 and 2. These forces are introduced by the inequality of angles Θ, Θ_1, and Θ_2. As soon as D and E appear, the cervical strap no longer makes equal angles with the sagittal plane on the right and left sides. Plainly, $T \sin \Theta$ does not equal $T \sin \Theta_1$ or $T \sin \Theta_2$. The sum of H_L and H_R must equal the difference between $T \sin \Theta_1$ and $T \sin \Theta$ or $T \sin \Theta_2$ and $T \sin \Theta$. H_L and H_R are generally undesirable except in the case where an appropriate crossbite is to be corrected simultaneously.

Discussion

In actual practice it is exceedingly difficult, if not impossible, to rationally design an appliance so that in a given case the total distally directed force is placed on one or the other molar. Fortunately, it is not necessary to work with exact forces in orthodontics and, without this restriction, it is relatively simple to incorporate dimensions D and E, consistent with the geometry of the face and tolerance of the patient, to create useful unilateral action. Experience has shown that the maxillary teeth on one side of the arch can be effectively retracted through the use of this method.

Frequently the patient will fail to verify unilateral action. There may be several reasons for this. One of the most common causes is that friction between the elastic neck strap and the neck temporarily offsets the equality of the applied forces at *j* and *k*. This is easily overcome by several movements of the head from side to side or by running a finger between the strap and neck. Another cause can be traced to excessive flexibility of the face bow which permits the final or seated values of A, C, D, and E to become different from the desired or planned values. It should be emphasized that dimensions A, D, and E are seated dimensions and represent distances when the appliance is being subjected to external forces. Usually the flexibility of the appliance is such that these dimensions are somewhat altered when the appliance is changed from the passive to the active state. To minimize error from this source, the use of large diameter wire for the extraoral bow is recommended. Finally, binding between the appliance and the buccal tubes can lead to unpredictable results. Such binding adds forces not shown in Figures 1 to 4 and these forces may either increase or decrease the unilateral effect depending on their directions. It is essential that the appliance fits passively into the buccal tubes to avoid the introduction of these forces or couples.

The above precautions hold also for symmetrical cervical traction. Any one or combination of these factors can produce partial unilateral action when it is not wanted. Usually the patient will voluntarily state that he doesn't feel any pressure on one side or the other. A check for neck friction, lack of symmetry of the lines of action of the applied forces with respect to the dental arch because of excessive flexibility of the appliance, and binding within the tubes will probably locate the reason for the non-uniform action.

Summary

A method for establishing unilateral cervical traction with a Kloehn-type of extraoral mechanism has been described. This involves the lateral displacement and lengthening of the arm of the face bow on the strong side relative to the arm on the weak side. The amount of this lateral displacement and lengthening will vary from case to case depending on the facial dimensions, tolerance of the patient and the amount of unilateral action wanted. Total or very nearly total unilateral action can be created, in the average case, when the lateral displacement is about three fourths of an inch and when the strong arm of the face bow is about two inches longer than the weak arm. These dimensions pertain to the active state of the appliance. Although this technique is quite effective in producing unilateral distal forces, it has the disadvantage of simultaneously subjecting the dental arch to side or lateral forces. These would be useful only in certain crossbite cases.

Study of unilateral action with the Kloehn extraoral mechanism also throws light on some of the reasons why unequal forces are sometimes experienced when uniform bilateral action is actually wanted. If the patient fails to verify the type of action desired, a check should be made to see that the appliance fits freely into the buccal tubes, that the appliance is not deformed excessively when it is seated and that the forces provided by the neck strap are not temporarily unbalanced due to frictional forces between the strap and the neck.

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Bibliography

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