Hyoid Changes Following Orthopedic Treatment of Mandibular Prognathism

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The position of the hyoid bone relative to the cranial base and the mandible has been of interest specifically as an indicator of tongue posture and function.[1] More generally, the hyoid bone, supported by its muscular and ligamentous attachments, has broader physiologic ramifications as it provides a functional interface between mandibular, laryngeal and cranial structures and the vital passageways these structures define. Thus, any alteration or change in position of the hyoid structures due to orthodontic treatment may have wide functional significance. The purpose of this study was to define the alterations in hyoid position that were associated with changes in mandibular form and growth produced by orthopedic chin-cup therapy.

LITERATURE REVIEW

The precise measurement of the positions of the hyoid bone has been difficult. Although cephalometric analysis has been the preferred research technique, slight variations in head position in the cephalostat, postural position of the spine, and the state of function (rest, swallow, etc.) have significant effects on hyoid position.[2-5] The fact that the hyoid bone is totally supported by soft tissue and thus lacks hard tissue reference adds to its relative instability.

Given these limitations of cephalometric technique, it has nevertheless been possible to make some definite conclusions concerning the normal position of the hyoid bone. King[2] reported that the hyoid bone remains constant in relation to the spine until the circumpubertal period when it tends to move slightly forward. Increases in vertical distance from the cranial base reflected increased posterior facial height during the age periods considered. Durzo and Brodie[6] confirmed King's findings noting that the hyoid bone tends to maintain its relative position to the mandible from the age of three years.

The belief that hyoid posture may be correlated with mandibular morphology and position has led to a consideration of various skeletal types. The several studies in this area, however, have disparate results with some authors positively correlating hyoid position to skeletal type[4,7,8,9] and others finding little correlation.[10,11] Gobeille and Bowman[12] and Cuozzo and Bowman[1] reported variations in the position of the hyoid bone relative to the mandible within a skeletal Class I context. This led to speculation that variability in hyoid position is only partly determined by mandibular posture. However, while there appear to be interpersonal variations in hyoid position, there is a relative constancy of hyoid position within the individual throughout growth periods.[6] The high degree of intrapersonal hyoid stability in relation to the mandible is characteristic for all Angle classifications of dentoskeletal type.[7,8]

Several authors have analyzed the effects of orthodontic and orthognathic surgical procedures on hyoid position and function. A series of experiments on altered tongue posture subsequent to placement of tongue cribs[1,2] showed that the hyoid positions shifted both posteriorly and inferiorly. Change varied as a function of hyoid position relative to the mandible. When the hyoid bone was initially close to the mandible, there was more change than when the hyoid was relatively distant from the mandible. Surgical retrusion of the mandible for correction of mandibular prognathism also results in changes in hyoid position. Postsurgically, the hyoid bone moves inferiorly and slightly pos-

teriorly.[13-16] At the same time there is a decrease in the distance from the posterior aspect of the mandibular symphysis to the body of the hyoid. Postoperatively, there appears to be little anteroposterior change of the relation of the hyoid bone to the vertebral column. The combined findings of the inferior hyoid positioning, with a small posterior displacement component, led to the conclusion that there are physiologic mechanisms to prevent hyoid related encroachment upon the pharyngeal airway.[13]

Alterations in mandibular morphology and position have been reported subsequent to orthopedic chin-cup therapy.[17,18] These studies have indicated that there is a distal or "clockwise" rotation of the mandibular complex with treatment. No report to date has dealt with possible implications of this therapy on the hyolaryngeal apparatus and pharyngeal space stability.

Materials and Methods

The material in this study consists of lateral cephalograms of thirty individuals with mandibular prognathism. Records were taken from the files of a private orthodontic practice. The sample group, a subset of a larger study on treatment effects of chin-cup therapy, was treated for a period of three years with an orthopedic chin-cup appliance for correction of skeletal Class III malocclusion.[17] The patients (16 males and 14 females) averaged six years of age at the start of treatment and were cephalometrically evaluated prior to and at the end of the three-year treatment period. No intraoral appliances were utilized prior to or during the therapy.

Appliance Design. The appliance used on the patients considered in this study was the chin-cup (Fig. 1). The extraoral appliance was designed to place posterior and superior forces on the temporomandibular joint along a line from pogonion to articulare. Occipital anchorage was used. During the 10 to 12 hours of appliance wear, force modules from 450 to 900 grams were activated bilaterally. After resolution of the maxillomandibular imbalance, the force on the chin-cup was reduced and the appliance was worn as a "retainer."

Fig. 1 The chin-cup appliance used on patients considered in this study generated posterior and superior forces from 450-900 grams along a line from the chin point to the temporomandibular articulation.

Cephalometric Technique. To standardize the cephalometric technique, all cephalograms were taken with the patient in habitual occlusion after the patient had swallowed (to avoid functional alteration of hyoid position). Four linear cephalometric measurements were made directly from the radiograph for purposes of evaluating change of hyoid position (Fig. 2). Anteroposterior change was monitored by first dropping a perpendicular from the SN plane to the most anterior and superior aspect of the hyoid body and, secondarily, measuring from the perpendicular line intersect with the SN plane to sella. The distance from menton to the body of the hyoid also reflected a primarily horizontal change. Vertical change was measured from ar-

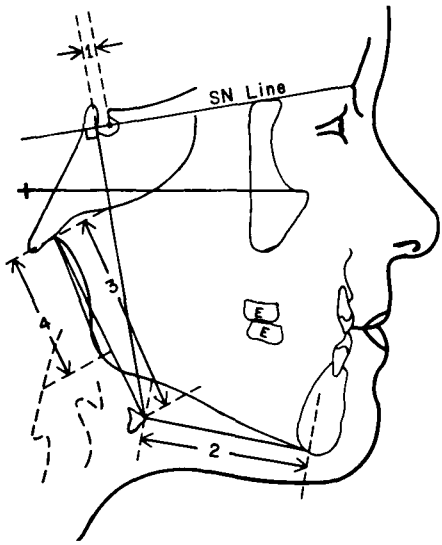

Fig. 2 The above tracing illustrates the measurements that were utilized in this study. Measurements 1 and 2 provide an index for measurement along the horizontal axis while measurements 3 and 4 provide an index for vertical assessments.

ticulare to the body of the hyoid. To compare this change with the gross alteration in the mandibular ramus length, the length from gonion to the articulare was also recorded. While measurement from the vertebral column to the hyoid body was considered, double determination cephalograms and tracings indicated that slight variations in subject posture changed vertebral position and produced significant error. Therefore, this measure was considered unreliable and was disregarded.

To provide a common 36 month observation period, all variations were reduced before computing the changes in variable values. Statistical comparisons (paired t-tests) were made between the measurements taken from the beginning and final films. Similar tests to evaluate initial and treatment differences due to sex were performed and proved to be insignificant. The entire group was thus considered in its entirety.

Findings

Anteroposterior change in position of the hyoid bone was indicated by two measurements. Projection of the final hyoid position upon the SN line showed a mean posterior movement of 1.3 millimeters when compared with the initial position. However, this change was not statistically significant. There was also a mean increase in the distance from menton to hyoid of 1.7 mm, but this too was statistically insignificant. Standard deviations of 6.5 mm in both anteroposterior measures made statistical significant comparison difficult.

Vertical change in hyoid bone position, as measured from articulare, increased 5.97 mm. Paired t-tests of the beginning and final measurements showed statistical significance at the .001 level. Mandibular ramus height increased only 2.6 millimeters, but this change, too, was found to be statistically significant at the .001 level reflecting growth over the 3-year period. Comparison between the increase in ramus height (growth index) and increase in distance from the hyoid bone to articulare indicated that there was more than a 3 millimeter greater downward vertical change in the hyoid bone relation than increase in the ramus length ($p < .001$).

Discussion

Previous reports of skeletal alterations subsequent to chin-cup therapy have indicated a posteroinferior, i.e., "clockwise" rotation of the facial complex, particularly the mandible. As expected, the hyoid apparatus appears to follow a similar pattern. While the anteroposterior changes monitored in this study were not statistically significant in themselves, they do indicate a trend for the hyoid bone moving slightly posteriorly or maintaining its relative AP position at the end of treatment (Fig. 3).

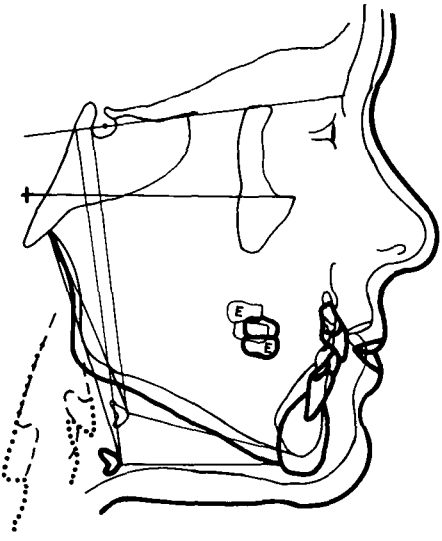

Fig. 3 This tracing illustrates the changes in hyoid position for one of the patients. The thin lines are taken from the pretreatment radiograph of the patient at six years, while the thick lines are taken from the posttreatment radiograph at nine years of age. Note the primarily inferior vertical change in hyoid position.

The report of a tendency toward increased menton to hyoid bone distance in the chin-cup therapy group is contrary to the findings in postorthognathic surgery cases where this distance decreased from 11 to 14 per cent. The important difference here is that in the surgical cases the mandible itself was shortened; in the chin-cup treatment, the mandible was allowed to grow and did increase in length, albeit that there was control of the mandibular prognathism pattern. The slight increase in the menton to hyoid distance in the chin-cup group is comparable to the "normal" changes to be expected during this growth period.[2]

The positional change of the hyoid bone, primarily in an inferior direction, is of particular note. Differences of over 3 mm between the vertical increase in ramus height and the inferior movement of the hyoid bone along approximately equally directed lines suggest that vertical change in hyoid posture was due to more than growth processes over the three-year observation period. The positional change of the hyoid bone is opposite to the reported stability of the structure in untreated individuals.[2,6,7,8] Surgical studies on mandibular "set back" procedures have noted similar inferior movement of the hyoid bone.[13,14]

It appears that, as the mandible is moved posteriorly relative to the other craniofacial structures, the tongue and hyoid bone are literally "carried" with it. However, with this posterior movement there is a tendency for the tongue and hyoid-laryngeal apparatus to encroach upon the vital oropharyngeal and laryngeal spaces. The spaces have limited variability as they are defined posteriorly by the bony spinal column and associated structures. As a result the posteriorly displaced hyoid-associated structures are guided to an inferior position to not compromise the vital passages. With increased posterior movement of the mandible there is an increased movement of the hyoid bone in an inferior direction. The changes in hyoid position reported in this study confirm the findings of similar studies and those on postorthognathic surgery patients suggesting that the stability and patency of the pharyngeal airway is a primary factor in hyoid positioning.

Functional integrity appears to be maintained with the inferior movement and the relative anteroposterior stability of the hyoid apparatus. Wolk reported that the hyoid functional pattern remains unchanged after surgical "set back" of the mandible, even though the whole cycle takes place in a relatively inferior position.[14] Clinical analysis of the present group also showed no difficulties in swallowing or tongue movements subsequent to therapy. Duration of the treatment and the

fact that it is a "growth guidance" procedure appears to allow for adequate functional adaptation to the altered hyoid position.

Summary

In this study 30 patients exhibiting mandibular prognathism were treated by the orthopedic chin-cup appliance for a three-year period. The patients began treatment at the age of six years and completed treatment at the age of nine years. As previously reported, chin-cup treatment resulted in a "clockwise" facial rotation with the mandible moving relatively posteriorly and inferiorly. Hyoid position measured in this study also tended to move slightly posteriorly but was primarily displaced in an inferior direction. The positional alteration exceeded in amount what might have been expected by growth alone. The inferior direction of change in hyoid and associated structures and the resultant lack of encroachment on the vital pharyngeal passageways suggests that stability and patency of the pharyngeal airway is a primary factor in hyoid positioning. The duration and "growth guidance" aspects of treatment allowed for functional as well as morphologic adaptation to the altered hyoid position.

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