# The Effects of a Mandibular Orthopedic Repositioning Appliance on Shoulder Strength

*Abstract*

The purpose of this study was to examine the effects of a mandibular orthopedic repositioning appliance (MORA) on human shoulder strength. Twenty volunteer undergraduate college students were randomly selected. The subjects were given oral examinations and two appliances were then constructed for them: A MORA, which repositioned the mandible in three dimensions as described by Gelb,[1] and a placebo appliance that did not alter the occlusion. Three bite conditions were then studied for each subject: centric occlusion, centric occlusion with the placebo splint inserted, and the position with the MORA inserted. The data for each subject were taken as he or she was seated in a stabilized chair, and the data were collected using a Cybex II dynamometer. Measurements were recorded for each of the six shoulder movements: abduction, adduction, flexion, extension, external rotation, and internal rotation.

Statistically significant results were obtained among the bite conditions for shoulder extension, peak torque; shoulder extension, average torque; and external rotation, average torque. Tukey's HSD post hoc tests indicated that the MORA bite condition yielded significantly higher strength scores than did the normal bite condition on each of these shoulder movement measurements. No significant differences were observed between the placebo and the normal bite condition. The authors thus concluded that the MORA splint does affect shoulder strength in certain movements.

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Until recently, the mandibular orthopedic repositioning appliance (MORA) was used primarily to treat the common malady of temporomandibular joint (TMJ) dysfunction. Although it is still used for that purpose, some dentists are now also recommending the MORA for another use: to help athletes reach their maximum potential.

The biomechanical relationship that exists between an individual's normal bite and his or her head posture can be demonstrated by testing the occlusion with bite paper.[2] When the head is laterally flexed and rotated, tooth contact becomes stronger on the side toward which the head is flexed. When the head extends, tooth contact becomes more posterior. When it flexes forward, the tooth contact becomes more anterior. Because it functions in this way, some authors hypothesize that the biomechanical unit consisting of the jaw, the head, the cervical spine, and the shoulder girdle becomes a more efficient system when an ideal mandibular posture is established with the MORA.

Athletic endorsements of the MORA have been numerous. A number of dentists and athletes[3-7] have claimed that the MORA increases strength in certain localized body parts. The validity of these claims has been suspect because the studies generally did not use acceptable controls. In addition, some of these experiments did not use tests of statistical significance to verify the results.

In spite of all these athletic endorsements, little is understood about the functioning of the appliance. Various scientific tests have scrutinized the effects of the MORA on strength in certain localized parts of the body.[8] Greenburg et al.[9] determined that no change occurred in shoulder abduction or adduction strength among three groups who were tested with an experimental MORA appliance, with a placebo MORA, and with no appliance.

Williams et al.[7] examined 23 male varsity athletes to determine the effects a MORA had in orienting the jaw in a supported rest position and in an empirically extended vertical dimension of occlusion. The authors conducted strength tests for shoulder abduction and adduction as well as knee flexion and extension. The Cybex II dynamometer* was used as the strength-measuring device. In that study, each subject was seated on a stool, and no stabilization of the trunk was indicated. It seems that the lack of stabilization could permit the athletes to use lateral leverage of the trunk during shoulder abduction and adduction. Williams et al. concluded in their study that mandibular position may affect appendage muscular strength, but there is some question about these findings because of the trunk stabilization problem and because no placebo appliance was tested against the MORA.

Because most previous research testing the influence of MORAs on strength has been equivocal in some way, our purpose in this investigation was to carefully isolate the effects of the MORA on human shoulder strength. Our study was concerned specifically with the function of the shoulder girdle in a controlled setting, using no appliance, a MORA, and a placebo splint.

## Subjects

For this investigation, we randomly selected 20 volunteer undergraduate students at the University of Illinois (nine males and 11 females). After each student had been given an oral examination by our first author, we took one maxillary and two mandibular alginate impressions for

*Cybex II Dynamometer—Lumex, Inc., Ronkonkoma, New York.

later construction of the appliances. None of the twenty subjects had prior knowledge of a MORA's appearance or how the appliance was constructed.

The subjects were divided into two groups. Group 1 consisted of five males and five females, each of whom exhibited Angle's Class I molar relationship with 40% or less anterior overbite. Group 2 consisted of four males and six females. Eight of these subjects exhibited Angle's Class II molar relation, one subject was a four-bicuspid post-orthodontic case, and one showed a Class I occlusion with an 80% anterior overbite.

## Splint Construction

Our objective in constructing the appliances was to fit each subject with a MORA and with a placebo splint. On the first mandibular cast, we fabricated a processed appliance as described by Gelb.[1] Indentations of the opposing maxillary lingual cusps were incorporated into the occlusal surface of this appliance (Figure 1A). For the second model, we constructed an appliance that did not alter centric or vertical occlusion (Figure 1B). No subject was aware of which splint was the MORA.

At the subject's second appointment, each appliance was adjusted intra-orally so the mandible would be in the optimal three-dimensional resting posture (determined by criteria established by Dr. Verban).

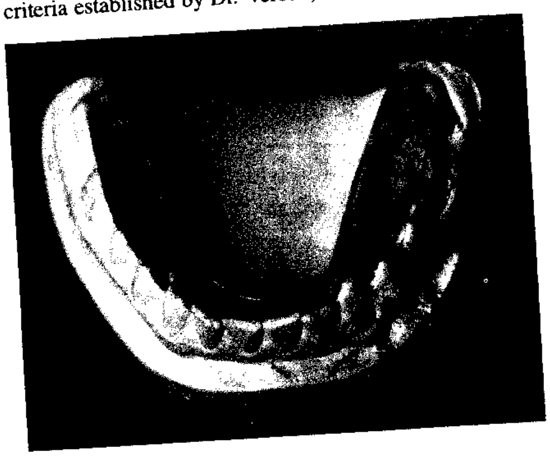

**FIG. 1A**
MORA used for the study.

## Testing Shoulder Function

A wooden chair was constructed so that it could be fixed to the floor yet could be adjusted for each subject's sitting

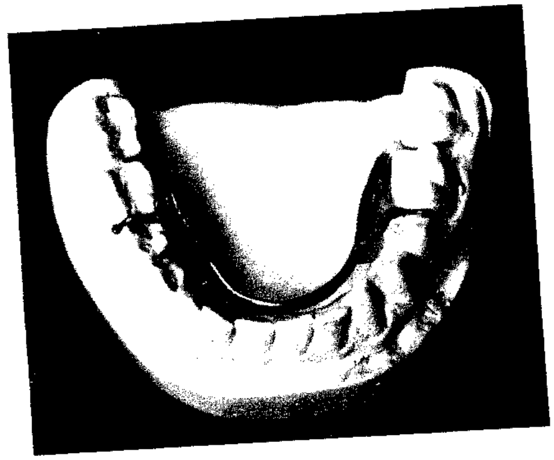

**FIG. 1B**
Placebo appliance used for the study.

height during all tests. The chair's vertical back came to at least the mid-thorax level for each subject. We used straps to stabilize the subject's trunk and opposite (non-dominant) shoulder so that the motion was restricted to the dominant shoulder.

We examined six shoulder movements in three sets of two movements each. All of the subjects performed each movement by grasping a handle attached to a Cybex II dynamometer which recorded the force-time data. The first set of movements was shoulder abduction and adduction. This was measured from the anatomical position, which was designated as zero degrees, through the full range of abduction and adduction back to the beginning position. The second set of movements we examined was shoulder flexion and extension. This also was measured from the anatomical position (zero degrees) through the full range of flexion and extension back to the initial position. The final set of movements was internal and external rotation. This began with the subject's shoulder in external rotation, the upper arm at 90 degrees abduction, and the elbow at 90 degrees flexion. (The arm was stabilized in this position throughout the test.) The subject then moved through the full range of internal rotation and back to the initial externally rotated position.

Three separate test sessions were administered for each subject. One set of movements was tested per session. The order of the sets was randomly assigned. The time between sessions was no less than one day and no more than three.

When the subjects arrived at the testing site, we measured their arm lengths so that we could properly orient the chair and the Cybex II dynamometer handle. Each subjec was then positioned in the chair, and the straps were put ir place. Each subject was given five slow warm-ups of the test movements to become familiar with the motions involved and to become accustomed to the testing device. We then requested the subject to complete a final practice trial at maximum effort so that he or she was familiar with how to give a maximum performance on the Cybex instrument. After the warm-ups, we then recorded measurements for each of the three bite conditions: (1) centric occlusion, (2) the placebo splint inserted, and (3) the MORA splint inserted. The order of bite condition was randomly assigned for each subject within each set of shoulder movements.

The subjects were first instructed to close their mouths and swallow. We then requested them to perform the movements with maximum effort. ("Pull on the handle as hard as you can.") Between trials the subjects were allowed to rest for 90 seconds.

Peak torque values were obtained for each of the six movements during all three conditions. Using a Numonic digitizer,* we also obtained total angular impulse for all the trials. The time of movement was measured using the Cybex charts, and average torques were calculated by dividing total impulse by time.

Our statistical analysis involved using a partially hierarchical three-factor ANOVA with bite condition, mandibular relationship group, and subjects as the three factors. Subjects were nested within the mandibular relationship groups. The interaction of bite condition and subjects (within groups) is used as the residual mean square for purposes of testing the main effect of bite condition. Each of the six dependent variables (shoulder movements) was subjected to this ANOVA, and peak torque and average torque were analyzed for each variable.

## Results

The ANOVAs revealed significant main effects of bite condition for the following shoulder measurements:

1. Extension, peak torque ($F(2, 36) = 8.40$, $p < .001$)
2. Extension, average torque ($F(2, 36) = 5.46$, $p < .01$)
3. External rotation, average torque ($F(2, 36) = 5.12$, $p < .05$)

No significant differences in the main effect of bite condition were noted for the other shoulder measurements.

Tables 1–3 display the bite condition means for each of the three variables with significant main effects. Since the F-test for interaction of the bite condition and the mandibular relationship group was non-significant in each case, the differential effects of bite condition may be assumed to be the same for both of the mandibular relationship groups (Group 1 and Group 2). Data may thus be pooled for these two groups so that we can focus attention on the main effect bite condition means (Tables 1–3).

**Table 1**
Bite Condition Means on Extension Peak Torque Scores*

| Mandibular Relationship | N | Bite Condition: Normal Bite | Placebo Splint | MORA | Overall Mandibular Relationship Means |
|---|---|---|---|---|---|
| Group 1 | 10 | 48.60 | 49.30 | 51.10 | 49.67 |
| Group 2 | 10 | 49.20 | 50.80 | 51.30 | 50.43 |
| Main Effect Bite Condition Means | | 48.90 | 50.05 | 51.20 | |

*All measurements recorded in foot-pounds.

**Table 2**
Bite Condition Means on Extension Average Torque Scores

| Mandibular Relationship | N | Bite Condition: Normal Bite | Placebo Splint | MORA | Overall Mandibular Relationship Means |
|---|---|---|---|---|---|
| Group 1 | 10 | 34.48 | 34.39 | 35.56 | 34.81 |
| Group 2 | 10 | 34.76 | 36.52 | 36.62 | 35.96 |
| Main Effect Bite Condition Means | | 34.62 | 35.46 | 36.09 | |

**Table 3**
Bite Condition Means on External Rotation Average Torque Scores

| Mandibular Relationship | N | Bite Condition: Normal Bite | Placebo Splint | MORA | Overall Mandibular Relationship Means |
|---|---|---|---|---|---|
| Group 1 | 10 | 11.30 | 11.33 | 12.04 | 11.56 |
| Group 2 | 10 | 10.97 | 11.13 | 11.50 | 11.20 |
| Main Effect Bite Condition Means | | 11.14 | 11.23 | 11.77 | |

We also made a posteriori pairwise comparisons within each set of main effect bite condition means using Tukey's HSD. A Scheffe test was also conducted within each set to compare the MORA bite mean with the average of the placebo and the normal bite means. This test in effect compared the MORA appliance to a combined control group whose normal bite was essentially not altered.

Table 4 shows the results of these a posteriori comparisons for each of the three shoulder movement variables. We can see that the MORA mean was significantly higher than the normal bite mean for all three variables. In addition, the MORA mean was significantly higher than the placebo mean for external rotation, average torque. Moreover, the placebo mean did not differ significantly from the normal bite mean for the three variables. Finally,

*Numonic Digitizer—Numonics Corporation. Landsdale. Pennsylvania.

**Table 4**
A Posteriori Comparisons on Main Effect Bite Condition Means

| Variable | Main Effect Bite Condition Means | | | Contrasts | | | |
|---|---|---|---|---|---|---|---|
| | $\bar{b}_1$ | $\bar{b}_2$ | $\bar{b}_3$ | $\bar{b}_3$-$\bar{b}_1$ | $\bar{b}_3$-$\bar{b}_2$ | $\bar{b}_2$-$\bar{b}_1$ | $\bar{b}_3$- ½ ($\bar{b}_1$ + $\bar{b}_2$) |
| Extension Peak Torque | 48.90 | 50.05 | 51.20 | 2.30** | 1.15 | 1.15 | 1.73** |
| Extension Average Torque | 34.62 | 35.46 | 36.09 | 1.47** | .63 | .84 | 1.05* |
| External Rotation Average Torque | 11.14 | 11.23 | 11.77 | .63* | .54* | .09 | .59* |

$\bar{b}_1$—Mean centric occlusion

$\bar{b}_2$—Mean placebo appliance inserted with centric occlusion

$\bar{b}_3$—Mean MORA inserted

*p ‹ .05

**p ‹ .01

we should note that for all three variables, the MORA mean was significantly greater than the average of the combined placebo and normal bite means.

## Discussion

With the exception of Williams et al.,[7] most research studies examining the effects of the MORA have concluded that three-dimensional repositioning of the mandible through use of this splint had little or no effect on appendage function. The findings of our study are in disagreement with these results and seem to present evidence that use of a MORA does have an effect on the shoulder's ability to create greater torque in certain movements. Although we found statistically significant results in only three of the twelve factors examined, it seems important that two of the six movements were involved: extension (peak torque and average torque) and external rotation (average torque).

It is difficult to identify specifically the isolated effects of the MORA on the musculature of the head, neck, and shoulders, but there does seem to be at least an indirect effect created by repositioning the mandible. One possible explanation is that the MORA may change the positioning of the cranium relative to the cervical vertebrae, and this would then change the angles of pull of various muscle groups associated with the cranium, the cervical vertebrae, and the shoulder girdle.

Stenger et al.[10] demonstrated how a change in mandibular position will alter not only the placement of the cranium over the cervical vertebrae, but also the angles of orientation of the vertebral bodies within the cervical vertebrae themselves. Because of that, those authors felt that custom-fitted mouthguards provided protection and relief for patients with head or neck injuries.

Our study attempted to look more specifically at the effects of changes in mandibular position on the biomechanical unit consisting of the head, the neck, and the shoulder girdle. Regardless of the isolated effects of mandibular position change, such change seems to have an effect on the function of the shoulder, as it creates greater torque in certain movements.

We recommend that further study be conducted that will attempt to isolate the effects of the MORA on the musculature of the shoulder girdle and on specific sports activities involving the upper limb segments. Activities in which shoulder rotation is involved extensively (such as the baseball pitch and the tennis serve) seem likely candidates for continuing research in this area.

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