Effects of 2 types of facemasks on condylar position

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Introduction: The aim of this study was to compare Delaire and Grummons protraction facemasks with a new articulator system (Amtech MG1, American Technologies, Brazil) that can record condylar positions.

Methods: Thirty-four patients treated with protraction facemask therapy were divided into 2 groups; 18 were treated with the Delaire facemask (DFM) and 16 with the Grummons facemask (GFM). The observation periods were 8.5 months for the DFM group and 10 months for the GFM group. Mandibular position indicator (MPI) recordings were taken with the new articulator system and evaluated before and after the protraction facemask therapies.

Results: MPI recordings in the sagittal plane showed forward and downward movement from centric relation to maximum intercuspal position for both condyles at the beginning of treatment for most patients. After treatment, the discrepancy between centric relation and maximum intercuspation was less in the DFM group than in the GFM group. However, more compressive movement of the condyles through the glenoid fossa was observed in the DFM group. Conclusions: Although the centric slide amount decreased more with the Delaire facemask compared with the Grummons facemask, patients treated with the Delaire facemask must be monitored for signs and symptoms of temporomandibular joint disorder. (Am J Orthod Dentofacial Orthop 2010;137:801-8)

Dentofacial orthopedics deals with the adjustment of relationships between and among the facial bones from heavy forces, or the stimulation and redirection of functional forces in the craniofacial complex. For patients with Class III malocclusion and maxillary deficiency, the use of maxillary protraction appliances is well documented in the orthodontic literature.

The conventional design of the facemask introduced by Dr Jean Delaire consists of a forehead support, a chin cup, a prelabial arch, and a metal frame (Fig 1, A). In order to protract the maxillary complex, the mandible and forehead are used as an anchorage unit with the Delaire facemask (DFM). In general, 700 to 800 g of orthopedic force is used to protract the maxilla with 70% to 75% of the force transmitted to the temporomandibular joint (TMJ). So, the TMJ must be considered under these heavy intermittent orthopedic forces. Dr Duane Grummons, who supported disengagement of the mandible during maxillary protraction, introduced a new type of facemask, called the Grummons facemask (GFM). It uses the zygomatic region as an anchorage unit for maxillary protraction, and consists of a forehead support, 2 suborbital pads, a prelabial arch, and a metal frame (Fig 1, B). The animal study of Jackson et al showed that maxillary protraction without a chin support caused no histologic changes in the TMJ. Although there are hypotheses about the effects of the DFM and the GFM on the TMJ, the validity of these assumptions are still controversial.

In the etiology of TMJ disorders, an important factor is the shift of the mandible due to the premature contacts in skeletal and dental Class III patients. Although TMJ sounds are less likely to occur in children than in adults, untreated mandibular deviations can lead to TMJ disorders. To determine the deviations in the TMJ and to view the condyles, contemporary radiology gives orthodontists various choices. However, trying to determine and evaluate 3-dimensional condylar positions by using 2-dimensional radiographic data is not reliable. Therefore, mounting the dental models in centric relation (CR) to the articulators with condylar position recording devices and applying the mandibular position indicator (MPI) procedure are recommended. Several companies such as SAM Präzisionstechnik GmbH (München, Germany), Panadent Corp. (Colton, CA, USA) and Whip Mix Corp. (Fort Collins, CO, USA) design and manufacture articulators that are widely used for this procedure. The instrumentation, working system, and reliability of these articulators.
are well documented in the literature. In this study, a new articulator system called the Amtech MG1 (American Technologies, Brazil) (Fig 2) was used to evaluate condylar positions.

The purposes of this study were (1) to record the condylar positions of patients with Class III malocclusion and maxillary deficiency in CR and maximum intercuspation (MI) positions, (2) to evaluate the centric slide (CS) amount and direction in Class III patients with maxillary deficiency with the MPI method, (3) to examine and compare the effects of the DFM and GFM on TMJ by using the MPI method.

MATERIAL AND METHODS

The parent sample was chosen from among the patients who were referred to Hacettepe University, Ankara, Turkey, with the chief complaint of anterior crossbite or edge-to-edge incisal relationship. To choose patients with maxillary deficiency, lateral cephalograms of these 50 patients (26 girls, 24 boys) were obtained. All cephalograms were traced, digitized, and evaluated by using the Jiffy Orthodontic Evaluation (JOE) program (version 5.0, Rocky Mountain Orthodontics, Denver, Colo). Mainly, the Ricketts and Steiner analyses were used to evaluate whether there was a maxillary deficiency. Furthermore, patients’ digitized tracings were superimposed with the race-specific visual norms on the nasion-basion line at nasion by using the same software. We included patients with ANB angle less than 1°, convexity value less than 1 mm, maxillary depth less than 90°, Wits appraisal of −1.5 mm or less, overjet of 0 mm or less, Class III or super Class I molar relationship, no permanent teeth congenitally missing or extracted before or during treatment, apparent maxillary deficiency seen on the superimpositions, prepubertal maturation stages 2 and 3 according to the cervical vertebral maturation method, and no functional anterior crossbite.

From the parent sample of 50 patients, 35 patients who satisfied the inclusion criteria were selected for this study. One patient moved to another city after the study started and was excluded. Thus, our study was completed with 34 patients (15 girls, 19 boys). Patients were selected randomly for DFM and GFM therapy. The DFM group consisted of 18 patients (10 girls, 8 boys), and the GFM group included 16 patients (5 girls, 11 boys). The mean ages at the start of treatment (T0) were 9.03 ± 0.82 years and 9.2 ± 1.1 years for the DFM and GFM groups, respectively.

To obtain the necessary data for the MPI recordings, maxillary and mandibular casts, MI and CR bite registrations, and face-bow recordings for each patient were taken before facemask treatment. The bilateral manipulation method was used to take the CR bite registrations, and another bite registration was also taken for the MI position. The patients’ maxillary and mandibular casts were mounted on the MG1 articulator (Fig 3) for the MPI procedure, as recommended by the manufacturer. First, the maxillary model was mounted to the articulator by using its custom face-bow. After mounting the maxillary cast, the articulator was placed upside down, and the CR wax registration was placed between the maxillary and mandibular casts. A layer of plaster was applied, and the lower part of the articulator was closed. After the plaster was set, condylar housings were replaced with condylar measurement drums, and the stickers were attached. The centers of the stickers indicated the condylar position in CR.
Then, the CR registration wax was replaced with the MI registration wax. An articulation paper was placed between the condyle and the measurement drum. The measurement drum was moved outward to contact the condyle. As a result, a registration corresponding to the condylar position at MI was obtained on the sticker. The articulator also allowed recording the mandibular sliding in a transverse direction from CR to MI. To obtain these data, the sticker was placed on the lower side of the upper frame. Casts were placed in their respective frames with the CR registration wax between them. An articulation paper was placed between the sticker and the transfer pin. Then the transfer pin was inserted from the hole on the lower frame until it contacted the sticker. The same procedure was repeated with the MI registration wax between the casts. As a result, 2 registration marks were recorded corresponding to transverse mandibular sliding.

On millimetric graph paper, the transverse (medio-lateral) shift was represented by $\Delta Y$ (Fig 4, A). The $\Delta Y$ value is negative when the MI position is on the left of the CR position. The $\Delta Y$ value is positive when the MI position is on the right of the CR position. Sagittal (anteroposterior and superoinferior) shifts of the condyles were marked and represented by $\Delta X$ and $\Delta Z$ (Fig 4, B), respectively. The $\Delta X$ value is positive when the MI position is anterior of the CR position. The $\Delta X$ value is negative when the MI position is posterior of the CR position. The $\Delta Z$ value is positive when the MI position is located inferior to the CR position.
The \( DZ \) value is negative when the MI position is superior to the CR position. Negative and positive values for \( DZ \) are also called compression and distraction, respectively.

To evaluate the reliability of the MG1 articulator, the MPI recordings were retaken from 10 randomly selected patients before facemask therapy. Random error was calculated by using Dahlberg’s formula. Method errors for the \( DX, DZ, \) and \( DY \) linear measurements were less than 0.3 mm.

In both groups, force was applied through a maxillary fixed labiolingual bar with an anterior point of application. A total of 600 to 700 g of force (300-350 g for each side) was applied between the lateral incisors and canines. The angle between the occlusal plane and the force vector of the facemask was approximately 20° to 25°, and the patients were instructed to wear the appliance 14 to 16 hours a day in both treatment groups.

### Table 1. Differences between DFM and GFM groups in \( \Delta X, \Delta Y, \) and \( \Delta Z \) at T0

<table>
<thead>
<tr>
<th></th>
<th>( DFM ) (n = 18)</th>
<th>( GFM ) (n = 16)</th>
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<tbody>
<tr>
<td>( T0 )</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>( \Delta X ) right condyle (mm)</td>
<td>1.13</td>
<td>1.46</td>
</tr>
<tr>
<td>( \Delta X ) left condyle (mm)</td>
<td>1.31</td>
<td>1.30</td>
</tr>
<tr>
<td>( \Delta Z ) right condyle (mm)</td>
<td>−0.97</td>
<td>0.96</td>
</tr>
<tr>
<td>( \Delta Z ) left condyle (mm)</td>
<td>−1.27</td>
<td>0.88</td>
</tr>
<tr>
<td>( \Delta Y )  (mm)</td>
<td>−0.06</td>
<td>1.02</td>
</tr>
</tbody>
</table>

**Fig 5.** Distribution of the MI positions relative to CR position: **A,** CS amount for the right condyle in the sagittal plane for the DFM group at T0; **B,** the left condyle.

**Fig 6.** Distribution of the MI positions relative to CR position: **A,** CS amount for the right condyle in the sagittal plane for the GFM group at T0; **B,** the left condyle.
After a positive overjet was achieved (T1), the MPI recordings were repeated as stated previously.

To evaluate the treatment changes between T0 and T1, Wilcoxon signed rank tests were used, and, to compare the T0 values of both groups, Mann-Whitney U tests were used. The level of significance was established as $P < 0.05$ for all statistical tests.

### RESULTS

The mean age of the patients in the DFM group was $9.03 \pm 0.82$ years, and the mean treatment time was $8.06 \pm 1.63$ months. The mean age of the patients in the GFM group was $9.20 \pm 1.10$ years, and the mean treatment time was $10.59 \pm 1.42$ months.

No statistically significant differences were found for the $\Delta X$ (anteroposterior), $\Delta Z$ (superoinferior), and $\Delta Y$ (mediolateral) distances between the groups at T0 (Table I). When the means of $\Delta X$ of all patients were evaluated together at T0, 26 patients (76.5%) had a protractive slide, 6 patients (17.7%) had a retractive slide, and 2 patients (5.8%) had no anteroposterior slide for the right condyle; 27 patients (79.4%) had a protractive slide, 6 patients (17.7%) had a retractive slide, and 1 patient (2.9%) had no anteroposterior slide for the left condyle. When the means of $\Delta Z$ of all patients were evaluated together at T0, 28 patients (82.4%) had distraction, 1 patient (2.9%) had compression and 5 patients (14.7%) had no superoinferior slide for the right condyle; 32 patients (94.2%) had distraction, 1 patient (2.9%) had compression, and 1 patient (2.9%) had no superoinferior slide for the left condyle. Graphical representations of CS relative to CR are shown in Figures 5 and 6 for the DFM and GFM groups, respectively. The transverse slide ($\Delta Y$) was equal (left slide in 17 patients and right slide in 17 patients) at T0.

There were statistically significant decreases for $\Delta X$ and $\Delta Z$ in both groups at T1 (Table II, Figs 7 and 8). However, when the groups were compared in terms of treatment type, there were significant differences for the $\Delta X$ values of the right and left condyles and the $\Delta Z$ value of the left condyle (Table III). Although there were no significant differences for the $\Delta Z$ value of the right condyle and the $\Delta Y$ value, the discrepancies between the CR and MI positions decreased more in the DFM group compared with the GFM group (Table III).

### DISCUSSION

In contemporary orthodontics, several methods can be used to evaluate condylar positions. Several researchers recommended conventional radiography,15,16 and others found that 2-dimensional imaging techniques are unreliable and insufficient for condylar position evaluation.10,17 Other than conventional radiography, it is hard to determine accurate condylar

### Table II. Treatment changes for $\Delta X$, $\Delta Y$, and $\Delta Z$ distances between T0 and T1

<table>
<thead>
<tr>
<th>Variable interval</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>P</th>
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<tr>
<td>DFM group</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta X$ right condyle (mm)</td>
<td>T0</td>
<td>1.13</td>
<td>1.46</td>
<td>1.48</td>
<td>−1.56</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>0.02</td>
<td>0.14</td>
<td>0.00</td>
<td>−0.25</td>
<td>0.47</td>
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<tr>
<td>$\Delta X$ left condyle (mm)</td>
<td>T0</td>
<td>1.31</td>
<td>1.30</td>
<td>1.43</td>
<td>−1.21</td>
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<tr>
<td></td>
<td>T1</td>
<td>0.08</td>
<td>0.20</td>
<td>0.00</td>
<td>−0.12</td>
<td>0.71</td>
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<td>0.97</td>
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<td>T1</td>
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<td>0.07</td>
<td>0.00</td>
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<td>T0</td>
<td>−1.27</td>
<td>0.88</td>
<td>−1.35</td>
<td>−3.03</td>
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<tr>
<td></td>
<td>T1</td>
<td>0.05</td>
<td>0.08</td>
<td>0.00</td>
<td>−0.27</td>
<td>0.25</td>
</tr>
<tr>
<td>$\Delta Y$ (mm)</td>
<td>T0</td>
<td>−0.06</td>
<td>1.02</td>
<td>−0.22</td>
<td>−2.21</td>
<td>1.72</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>−0.01</td>
<td>0.06</td>
<td>0.00</td>
<td>−0.17</td>
<td>0.18</td>
</tr>
<tr>
<td>GFM group</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$\Delta X$ right condyle (mm)</td>
<td>T0</td>
<td>0.81</td>
<td>1.10</td>
<td>1.08</td>
<td>−1.43</td>
<td>2.34</td>
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<tr>
<td></td>
<td>T1</td>
<td>0.43</td>
<td>0.72</td>
<td>0.38</td>
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<tr>
<td>$\Delta X$ left condyle (mm)</td>
<td>T0</td>
<td>0.90</td>
<td>1.42</td>
<td>1.35</td>
<td>−2.78</td>
<td>2.30</td>
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<tr>
<td></td>
<td>T1</td>
<td>0.26</td>
<td>0.54</td>
<td>0.30</td>
<td>−1.28</td>
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<tr>
<td>$\Delta Z$ right condyle (mm)</td>
<td>T0</td>
<td>−0.90</td>
<td>0.57</td>
<td>−1.06</td>
<td>−2.00</td>
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</tr>
<tr>
<td></td>
<td>T1</td>
<td>−0.59</td>
<td>0.47</td>
<td>−0.65</td>
<td>−1.48</td>
<td>0.25</td>
</tr>
<tr>
<td>$\Delta Z$ left condyle (mm)</td>
<td>T0</td>
<td>−1.16</td>
<td>0.79</td>
<td>−1.01</td>
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<tr>
<td></td>
<td>T1</td>
<td>−0.51</td>
<td>0.55</td>
<td>−0.38</td>
<td>−1.76</td>
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<tr>
<td>$\Delta Y$ (mm)</td>
<td>T0</td>
<td>0.07</td>
<td>0.78</td>
<td>0.32</td>
<td>−1.62</td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>0.06</td>
<td>0.18</td>
<td>0.05</td>
<td>−0.26</td>
<td>0.33</td>
</tr>
</tbody>
</table>

*P < 0.05; †P < 0.01; ‡P < 0.001.
positions from a tomogram or a magnetic resonance image. For this reason, to evaluate 3-dimensional condylar positions and shifts of the condyles, the use of articulators and the MPI procedure are recommended.

CR of the condyles is determined by several methods. The bilateral manipulation method described by Dawson was used in this study. Previous studies showed high repeatability of this method. The condyles could be guided easily to the superoanterior position in the glenoid fossa, and the method is learned easily compared with other techniques. Patient position is important when taking a CR bite registration. All of the CR bite registrations were taken by one operator (H.E.) with the patient in supine position. It was suggested that the supine position could lead to contraction of the genioglossus, lateral and medial pterygoid muscles, as a defense mechanism to prevent airway obstruction. Therefore, errors can occur while taking CR bite registrations. However, Campos et al showed no difference electromyographically for those muscles with the patient either in supine or upright position. Timing is important when manipulating the mandible so that the muscles that protrude the mandible are not triggered to contract by applying pressure at the wrong time or in the wrong direction.

The MG1 is an ARCON-type semiadjustable articulator where the condylar ball is located on the lower frame and the guiding surface is located on the upper frame of the articulator, mimicking the actual TMJ. (Fig 2). MPI procedure is similar to the previously

Fig 7. Distribution of the MI positions relative to CR position: A, CS amount for the right condyle in the sagittal plane for the DFM group at T1; B, the left condyle.

Fig 8. Distribution of the MI positions relative to CR position: A, CS amount for the right condyle in the sagittal plane for the GFM group at T1; B, the left condyle.
and decreases were found for the (Figs 7 and 8). Although statistically significant masks, the CR and MI positions approached each other was evaluated at T1, we observed that, with both face-untreated subjects is a well-known phenomenon.13,29 In the sagittal plane measurements made before the start of therapy. The repeatability and reliability of the MG1 system the mechanism is not as complex as for the SAM articulatormentioned articulator systems and it is rather easy, and the mechanism is not as complex as for the SAM articulator. The repeatability and reliability of the MG1 system are in acceptable limits, according to the consecutive measurements made before the start of therapy.

The discrepancy between CR and MI positions in untreated subjects is a well-known phenomenon.13,29 The evaluation of the subjects at T0 showed similar results to previous studies.19,29 In the sagittal plane (ΔX and ΔZ), downward and forward movement of the condyles in the glenoid fossa was observed for most patients at T0 (Figs 5 and 6). It was suggested that patients with maxillary deficiency tend to position their mandibles anteriorly as a result of undesirable anterior tooth contact.30

An important goal of occlusal therapy is the coincidence of CR and MI positions.13 When the MPI data was evaluated at T1, we observed that, with both face-masks, the CR and MI positions approached each other (Figs 7 and 8). Although statistically significant decreases were found for the ΔX and ΔZ values in both groups (Table II), the coincidence of CR and MI positions was much more prominent in the DFM group (Table III, Fig 7). It was found that the discrepancy between the CR and MI positions persisted in the GFM group (Fig 8). This difference probably appeared because of the lack of a chincup in the design of the GFM and the freedom of movement of the mandible. However, less compression of the condyle through the glenoid fossa was observed in the GFM group. In the DFM group, only one patient’s MI position was above the CR position (compression) at T0 (Fig 5). It was an interesting finding that, with the DFM, compression was seen in 9 patients (Fig 7), but only 1 patient had compression at T1 in the GFM group (Fig 8). According to Deguchi and McNamara,31 the glenoid fossa can be widened and deepened with a chincup. Since the DFM includes a chincup in its design, the position of MI above CR might be an expected result. It is still not clear in the literature whether the compressive or distractive position of the condyles are more hazardous to the TMJ, but Slavicek32,33 stated that compression is a general finding in patients with internal derangements. The reasons that Grummons4 changed the conventional design of the facemask were not only to present an alternative method for the treatment of Class III malocclusions, but also to prevent the undesirable effects of the chincup over the TMJ.

Although the treatment effect of DFM is well documented in the literature, there are few studies and insufficient cephalometric data concerning the GFM.4,34 So, a main goal of this study was to increase our knowledge about the effects of the GFM on the dentofacial complex by means of MPI and cephalometrics. The effects of the DFM and GFM on dentofacial structures and dentitions have also been compared with cephalometrics in the second part of this study. Our current research focuses especially on comparison of the 2 facemasks with the MPI procedure. However, it will be relevant to present some of our cephalometric findings briefly to support our conclusions about this study.

Our cephalometric findings showed that the maxilla moved anteriorly with both facemasks. Although the force vectors of the facemasks were adjusted to be 20° to 25° with respect to the occlusal plane, counterclockwise rotation of the palatal plane was observed. The counterclockwise rotation of the palatal plane in the GFM group was more prominent than in the DFM group. As for the mandible, posterior rotation was evident in the DFM group. However, the mandible continued its normal forward and downward growth in the GFM group. Grummons4 defended the idea that the mandible should be released during maxillary protraction so as not to disturb condyle-disc integrity. Therefore, he suggested that protraction of the maxillary arch leads to anterior repositioning of the mandible; thus, optimization of the condyle-disc complex would be better. Our cephalometric and MPI findings agreed with those suggestions.

However, it is impossible to say whether the MPI and cephalometric changes during treatment are caused only by the facemasks. The TMJ is under constant modification by growth when the age range of the groups is taken into account. More than 50% of the eminence development has been completed by this age,35 but the condyle and gelenoid fossa are still under modification and variation.36 Also, simultaneously, the occlusion can change because of deciduous tooth loss and permanent tooth eruption. It would, of course, be better if the treatment groups were compared with a control group to observe the treatment effects, but this was impossible due to ethical reasons.

Therefore, it can be concluded that, as for all appliances used in orthodontic practice, the DFM and GFM also have advantages and disadvantages over each other.

| Table III. Intergroup treatment differences for ΔX, ΔY, and ΔZ values between T0 and T1 |
|---------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                                           | DFM (n = 18)      | GFM (n = 16)      | P               |
|---------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| ΔX right condyle (mm)                      | -1.09 ± 1.44      | -0.38 ± 0.55      | 0.046*            |
| ΔX left condyle (mm)                       | -1.45 ± 0.95      | -0.64 ± 0.96      | 0.044*            |
| ΔZ right condyle (mm)                      | 1.01 ± 0.97       | 0.31 ± 0.16       | 0.075             |
| ΔZ left condyle (mm)                       | 1.32 ± 0.88       | 0.65 ± 0.42       | 0.007             |
| ΔY (mm)                                    | 0.05 ± 1.03       | -0.02 ± 0.74      | 0.918             |

*P <0.05; †P <.01.
Although the CS amount decreased more with the DFM compared with the GFM, patients using the DFM must be monitored for any signs and symptoms concerning the TMJ.

**CONCLUSIONS**

1. Repeatability and reliability of the MG1 articulator was within acceptable limits.
2. A discrepancy between CR and MI positions was observed for all patients with Class III maxillary retrusion at T0.
3. The CS amount decreased more with the DFM compared with the GFM.
4. The condyles tended to move superiorly in the glenoid fossa after the use of the DFM, but that effect was not observed with the GFM.

**REFERENCES**