Aim The aim of this study was to assess the dynamic activity of the mandible by means of a computerised kinesiograph in Class II patients treated with orthodontic therapy and to compare the results of this group with those of a sample of untreated Class II patients.

Methods Twenty young adolescents who had undergone orthodontic treatment for correction of Class II malocclusion and twenty age and sex-matched adolescents exhibiting Class II malocclusion, whose parents refused the orthodontic treatment, were enrolled. Maximum vertical opening (MVO), maximum anterior-posterior movement (MAPM), maximum right deviation (MRD), maximum left deviation (MLD), MVO/MAPM ratio, maximum velocity in opening (MVIO), maximum velocity in closure (MVIC), verticality (ID-V), anterior-posteriority (ID-AP) and laterality (ID-L) were recorded during the kinesiographic evaluations. Differences in the kinesiographic data were analysed using the Wilcoxon sum rank test; data are expressed as means and standard deviations (SD). Differences between groups in age were analysed using unpaired t-test, while differences in gender distribution were assessed using the Fisher’s exact test. The level of significance was set at p < 0.05.

Results No differences were detected in the distribution of sex and age between the two groups. Significant differences between the two groups were observed for MVO, MAPM, that were higher in the control group, and MLD, which was higher in the case group; no other significant differences were detected for MRD, MVO/MAPM, MVIO, ID-V, ID-AP, ID-L.

Conclusion Orthodontic treatment of young patients with Class II malocclusion may reduce the maximum vertical opening as well as the maximum anterior-posterior movement and enhance the lateral displacement; however, further studies are needed to assess the relationship between impaired mandible kinetics of orthodontic treatment in patients with Class II malocclusion and craniomandibular disorders.

Keywords Class II Malocclusion; Kinesiography; Mandible; Orthodontic treatment

Effects of correction of Class II malocclusion on the kinesiographic pattern of young adolescents: a case-control study

Introduction

The study of mandibular movement dynamics is not new, but in the Seventies Jankelson et al. [1975] introduced the kinesiograph as an instrument for diagnosis and clinical research in dentistry. Kinesiology describes the mandibular movements on the basis of anatomic, physiological and mechanical principles. The movements of the mandible are primarily determined by the position of the cusps because the condyles have to move according to a certain trajectory, whereas the mandible movements are controlled by muscles [Fushimi, 1987]. The teeth make possible the guidance of the mandibular movements in several ways: the posterior teeth maintain vertical support during closing and guide the mandible into maximum intercuspation [Ramfjord, 1983], the front teeth participate in the movements of protrusion, while the canines and the premolars participate in lateral movements. The K7 diagnostic system (K7/CMS; Myotronics-Noromed, Inc., Tukwila, WA, USA) is one example of a computerised device designed for the specific purpose of recording mandibular movements by tracking a magnet secured to the lower incisors. This diagnostic technique uses the movement of the mandibular incisor to assess the full range of mandibular movements without interfering with its physiologic functions and ease of access [Angle, 1899].

The primary objective of orthodontic treatment is to achieve ideal positional relationships among the teeth within and between the arches [Andrews, 1972; Andrews, 1989; Ahlgren, 1967]. Positional corrections can be made by moving the teeth and/or by modifying the skeletal structures and growth of the cranial and facial skeleton. An Angle’s Class I occlusion between canines and molars is considered to be the orthodontic target, in terms of both aesthetics and functionality,
for patients presenting with substantial malocclusion [Andrews, 1989; Ahlgren, 1967]. To better justify treatment, we often assume that malocclusions produce abnormal chewing patterns. The study of Ahlgren [1967] suggests that the chewing patterns of children with various forms of malocclusion tend to be more irregular than those with normal occlusion. Gibbs et al. [1971] also reported more irregular chewing patterns among subjects with malocclusion.

The purpose of this study was to assess the dynamic activity of the mandible by using a computerised kinesiograph in Class II patients treated with orthodontic therapy and to compare it with that of a sample of untreated Class II patients.

Materials and methods

Patients selection

This study was conducted in accordance with the Declaration of Helsinki. The Scientific Ethics Committee of the University of L'Aquila, L'Aquila, Italy, approved the study and an informed consent was obtained from each subject.

Twenty young adolescents who had undergone orthodontic treatment for correction of Class II malocclusion were recruited in the study; twenty age and sex-matched adolescents which showed a Class II malocclusion, whose parents refused the orthodontic treatment, were enrolled and acted as control group. Patients were qualified as cases if they satisfied the following inclusion criteria: molar and canine Class I, overjet 0 to 4 mm, absence of asymmetry or rotations, compliance of contact points, correct Spee's curve, ANB angle 0°–4° with Fh^1 = 110° ± 4, FMA = 25 ± 10, and IMPA = 90 ± 4.

Patients in the control group and in the case group were selected before the orthodontic treatment according to the following inclusion criteria: bilateral Class II molar relationship of at least 1/2 cusp with no unilateral posterior cross-bite. The diagnosis of Class II malocclusion was based on intra-oral photographs and dental casts; patients in the case group were initially treated by a rapid maxillary expansion that was left in place as a passive retainer for 3 months, then, they underwent an orthodontic finalisation performed with fixed appliances.

Patients were excluded if they showed any temporomandibular joint noise at the clinical examination, capsular or muscle pain on palpation, trauma in the dentofacial region, systemic diseases of joints or muscles, need for surgical orthodontic treatment, dental or craniofacial syndromes, a history of severe orthodontic treatment, anomalies in number or shape of permanent teeth, extractions of any permanent teeth or were taking systemic medications such as steroids.

Kinesiographic measurements and instrumentation

Mandibular movements were recorded according to the protocol of Monaco et al. [Monaco et al. 2012; Monaco et al., 2008a; Monaco et al. 2008b; Monaco et al., 2006] using a computerised kinesiograph (K7/ CMS; Myotronics-Noromed, Inc., Tukwila, WA, USA) that measures jaw movements with an accuracy of 0.1 mm. A lightweight array (113 gr) with multiple sensors and containing 8 magnetic sensors, tracked the motion of a magnet (CMS Magnet; Myotronics-Noromed, Inc., Tukwila WA, USA), that was attached at the lower
interincisor point. The kinesiograph was interfaced with a computer for data storage and subsequent software analysis (K7 Program, Myotronics-Noromed, Inc., Tukwila WA, USA). The kinesiographic array was mounted on the subject’s head, and the optimal position of the magnet for the recording of the mandibular movements was monitored by software.

For kinesiographic measurements, the maximum vertical opening (MVO), defined as the vertical length of the maximum voluntary opening, the maximum anterior-posterior movement (MAPM), defined as the horizontal length of the maximum voluntary opening, the maximum lateral excursion, defined as the maximum right deviation (MRD) or the maximum left deviation (MLD) during the maximum voluntary opening and the MVO/MAPM ratio, were measured on the SCAN 1 of the software. On the SCAN 2, the maximum velocity in opening (MVIO) and the maximum velocity in closure (MVIC) were measured. The recordings of the SCAN 1 and 2 started asking the patients to occlude the teeth and, then, to open as wide as possible the mouth: in the SCAN 1 the patients were asked to perform these movements for five consecutive times, while in the SCAN 2 the patients were asked to perform those movements as far and wide as possible for ten consecutive times. For the recording of the SCAN 3, the patients were asked to close their eyes and, starting from the mandible rest position, to occlude the teeth; after two seconds from the occlusal contact, the patients were asked to quickly open and return in occlusal contact (tap-tap phase). For each patient, at least 3 consecutive tap-tap phases were recorded; the achievement of the occlusal contact during each tap-tap phase was defined as the presence on the vertical component (Fig. 1, blue line) of the kinesiographic tracing of an horizontal line located at the same height of the first occlusal contact (Fig. 1). After the tap-tap phase, the patients kept their habitual occlusal position for at least one second, and then they were asked to protrude the mandible. In the SCAN 3 the interocclusal distance (ID) at rest was recorded in its threedimensional components: verticality (ID-V), anterior-posteriority (ID-AP) and laterality (ID-L), defined as the difference between the basal and the highest level of the blue, red and green track, respectively (Fig. 1). All kinesiographic variables were expressed in mm.

Sample size calculation
The sample size calculation determined that 16 subjects per treatment arm would provide a 80% power to detect a true difference of 5 mm in the MVO between the case and the control group, assuming that the common standard deviation is 0.5. Accordingly, a sample of 20 subjects per arm was recruited to overcome the possibility of dropouts.

Statistical analysis
Statistical analysis was performed using SAS 9.2. The level of significance was assumed to be p < 0.05 for all tests. Data were tested for the normality of the distribution with the Shapiro-Wilk test, that indicate an abnormal distribution of all kinesiographic data, as well as the patients age in the three groups; therefore, differences in the kinesiographic data were analysed using the Wilcoxon sum rank test; data are expressed as means and standard deviations (SD). Differences between groups in age were analysed using the unpaired t-test, while differences in gender distribution were assessed using the Fisher's exact test.

Results
No differences were detected in the distribution of sex and age between the two groups (Table 1). Significant

<table>
<thead>
<tr>
<th>CASE</th>
<th>CONTROL</th>
<th>LEVEL OF SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>14.48±1.51</td>
<td>14.2±1.48</td>
</tr>
<tr>
<td>Gender (F/M)</td>
<td>11/9</td>
<td>9/11</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CASE</th>
<th>CONTROL</th>
<th>LEVEL OF SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVO</td>
<td>41.03±4.74</td>
<td>31.66±12</td>
</tr>
<tr>
<td>MAPM</td>
<td>25.15±6.82</td>
<td>19.22±8.04</td>
</tr>
<tr>
<td>MRD</td>
<td>2.54±1.5</td>
<td>2.29±2.93</td>
</tr>
<tr>
<td>MLD</td>
<td>2.65±1.41</td>
<td>4.24±2.73</td>
</tr>
<tr>
<td>MVO/MAPM</td>
<td>1.72±0.4</td>
<td>1.67±0.72</td>
</tr>
<tr>
<td>MVIO</td>
<td>227.66±114.5</td>
<td>188.15±105.01</td>
</tr>
<tr>
<td>MVIC</td>
<td>291.28±89.45</td>
<td>220.89±117.27</td>
</tr>
<tr>
<td>ID-V</td>
<td>1.61±1.86</td>
<td>1.11±1.31</td>
</tr>
<tr>
<td>ID-AP</td>
<td>0.84±1.13</td>
<td>0.73±0.83</td>
</tr>
<tr>
<td>ID-L</td>
<td>0.4±0.55</td>
<td>0.28±0.24</td>
</tr>
</tbody>
</table>
differences between the two groups were observed for MVO, MAPM, that were higher in the control group, and MLD, that was higher in the case group, no other significant differences were detected for MRD, MVO/MAPM, MVIC, ID-V, ID-AP, ID-L (Table 2).

Discussion

The present study evaluated the dynamic activity of Class II patients treated by orthodontic therapy and untreated Class II patients. Mandibular movements were recorded with a kinesiograph that used the mandibular incisors as the reference point. Other authors studied the accuracy of this method and concluded that the linearity and quantitative accuracy ranged from an error of 0 to 0.1 mm at intercuspation [Neill, 1984; Kang et al., 1991]. Among the advantages of this technique are the ability of mandibular incisor movement to reflect a full range of mandibular motion without interfering with physiologic functions, the ability of individuals in a normal range to have precise proprioception, and the ease of access [Ferrario et al., 1992]. In several studies, the ability to open the mouth and move the mandible in any direction has been correlated with the subject’s age and body height [Nielsen et al., 1990] and might be reduced in case of craniomandibular disorders. In this study, no statistical differences between the control and Class II subjects were found in the distribution of sex and age because the patients had similar age. Our results showed that significant differences between the two groups were observed for MVO, MAPM, that were higher in the case group, and MLD, that was higher in the control group.

Taken together our data suggest that young adolescents who had undergone orthodontic treatment for the Class II correction show impairment of mandible kinetics compared to control subjects.

Our kinesiographic assessment of the velocities of the jaw during normal and fast opening and closing movements showed no significant differences between the study subjects and control group. Since the software of the K7 system used in the present study evaluates the velocity of the jaw during opening and closing movements and not during mastication, it is impossible to compare these results with other studies.

Results of this study also demonstrated no other significant differences for MRD, MVO/MAPM, ID-V, ID-AP, ID-L.

However, few studies in literature are available on this topic, and further prospective studies with adequate sample size and proper methodology are needed to assess the effects of the orthodontic treatment in patients with Class II malocclusion and the correlation between impaired mandible kinetics suggested in our study and craniomandibular disorders.

References

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