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Assessment of mandibular growth and response to functional appliance treatment in prepubertal patients with different auxologic categories

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ARTICLE INFO
Article history:
Received 22 September 2007
Accepted 6 September 2009

Keywords:
Functional treatment
Growth potential
Auxologic categories
Mandibular response
Class II malocclusion

ABSTRACT
Objective: To assess mandibular growth and response to functional appliance treatment in different Petrovic’s auxologic categories and to investigate diagnostic and prognostic usefulness of the Lavergne-Petrovic’s flow diagram.

Materials and methods: Eighteen patients with class II malocclusion (ANB ≥ 4°, dental class II) were selected and divided into 4 groups according to the auxologic categories. Category 2 group had 4 patients, category 3 group had 5, category 4 group had 5 and category 5 group had 4. In order to obtain patient’s growth curves and detect the correct treatment time, patient’s height was measured every 3 months. This method was supported by the cervical vertebral maturation method for the assessment of mandibular growth. Functional appliance and/or class II elastics, during the fixed appliance phase, were used to correct skeletal and dental relationships. Average treatment time was 31 months (Range 28-36 months). CoGn and ANB were detected in pre-treatment and post-treatment radiographs in order to assess mandibular growth.

Results: The highest growth was in category 5, the lowest in category 2. Rotational type improvement was generally observed.

Conclusions: In prepubertal class II patients, treatment success not only depends on appliance choice, clinician’s ability and correct treatment time, but also on individual growth potential and facial type. Therefore Lavergne-Petrovic’s flow diagram could become a great diagnostic and prognostic aid for the orthodontist.

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1. Introduction

Class II malocclusion can result from many causal factors, both dental and skeletal. Although maxillary protrusion and mandibular retrusion can be possible causative factors of this kind of malocclusion, it has been reported that class II malocclusion is commonly associated with mandibular retrusion.1-5 In growing patients, when the class II is mainly related to the retrognathic mandible, the primary treatment is functional appliance therapy in order to enhance mandibular growth. Success of this treatment modality depends on several
factors, such as appliance choice, clinician’s ability, treatment timing and patient growth response. Although several authors underlined the efficiency and the effectiveness of the most common functional appliances and the importance to begin the treatment when the growth peak is upcoming, less emphasis has been given to individual growth response possibilities. Therefore many methods have been developed in order to detect the right skeletal age and several functional appliances have been proposed to improve mandibular deficiency, but not much is known about the individual ability to positive responses to functional stimuli as referred to sagittal growth pattern, morphogenetic rotation of the mandible and biologic features of cartilaginous and bone growth.

As far as growth pattern, a few authors searched for prognostics elements to assess growth potentiality. Because a poor growth potential during treatment prevents the achievement of a skeletal correction and the improvement of the facial profile, it should be desirable to know in advance a given patient’s growth potential and response to orthodontic treatment.

By investigating the mandibular tissue level growth potential and responsiveness to orthodontic, orthopaedic and functional appliances, Petrovic, Lavergne and Stutzmann developed a cephalometrically based flow diagram that allows that recognizes patient’s auxologic (tissue level growth) category.

According to their classification, mandibular tissue level growth increases from category 1 to category 6 gradually. These six tissue level growth categories would be specifically linked to 11 rotational types, which can be cephalometrically identified. Once the rotational type is determined, the corresponding growth category is found. The 11 rotational types are appointed by a trinomial label. In each label, the 3 successive symbols represent:

1. Mandibular growth rotation, posterior (P), neutral (R), and anterior (A);
2. A numeric assessment of the difference in growth potential between the mandible and maxilla: 1, mandible = maxilla; 2, mandible < maxilla; 3, mandible > maxilla;
3. The sagittal interjawn relationship: distal (D), normal (N), and mesial (M).

According to the vertical dimension each rotational type is further subdivided into open bite (OB), normal bite (N), or deep bite (DB). 33 rotational groups can be finally counted.

The rotational type and growth category determination should permit to know in advance patient’s growth potential and response to orthodontic treatment, giving the orthodontist a great diagnostic and prognostic aid.

2. Material and methods

Eighteen patients with class II malocclusion (ANB ≥ 4°, dental class II) were selected and divided into 4 groups according to the auxologic categories. Category 2 group had 4 patients, category 3 group had 5, category 4 group had 5 and category 5 group had 4. In order to obtain patient’s growth curves and detect the correct treatment time, patient’s height was measured every 3 months. This method was supported by the cervical vertebral maturation method for the assessment of mandibular growth.

Functional appliance and/or class II elastics, during the fixed appliance phase, were used to correct skeletal and dental relationships of these prepubertal patients. Patients had been wearing functional appliance for 12-18 months for not less than 14 hours a day.

Functional appliance phase was then followed by a fixed appliance therapy, which included the use of class II elastics. Patients had been wearing class II elastics for 8-14 months for 14-16 hours a day.

Treatment time was an average length was 31 months.

Pre-treatment and post-treatment lateral skull radiographs were analysed in order to detect possible relationships between pre-treatment auxologic category and treatment response.

Rotational types, essential to detect auxologic categories, and rotational groups were identified in both pre-treatment and post-treatment radiographs in order to assess rotational modifications.

Auxologic categories were identified in the pre-treatment radiograph using Lavergne-Petrovic’s flow diagram. According to this method, T1 was the first value to be calculated:

\[ T1 = \text{expected ML/NSL} - \text{measured ML/NSL} \]

\[ \text{expected ML/NSL} = 192 - 2 \text{ (measured SNB)} \]

ML/NSL: angle between mandibular line and nasion-sella-line

NL/NSL: angle between nasal line and nasion sella-line

The second value was T2:

\[ T2 = \text{expected NL/NSL} - \text{measured NL/NSL} \]

\[ \text{expected NL/NSL} = \frac{\text{measured ML/NSL}}{2 -7} \]

The third value was obtained measuring the ANB angle:

\[ T3 = \text{ANB} \]

After the patient’s rotational type was identified, CoGn and ANB were measured in the pre-treatment and post-treatment cephalograms.

The annual CoGn increases and ANB changes were also calculated.

Then average CoGn annual increases and ANB average modifications with standard deviations and C.I. (Confidence Interval) were calculated in each category and in the whole sample (Table 1).

The author(s) declare that the work has been realized in agreement with the Helsinki Declaration principles and that the Informed Consent has been achieved from all the participants involved in the study.

3. Results

Annual average CoGn increase resulted (Fig. 1; Table 2):

- 2.27 mm in growth category 2 (CI 95% = 0.36)
- 2.93 mm in growth category 3 (CI 95% = 0.52)
- 3.41 mm in growth category 4 (CI 95% = 0.33)
- 3.89 mm in growth category 5 (CI 95% = 0.14)
- 3.13 mm in the whole sample (CI 95% = 0.52)

Average ANB decrease was (Fig. 2; Table 3):

- 2.5° in growth category 2 (CI 95% = 0.57)
Table 1 – Age, treatment length, pre-treatment rotational group, pre-treatment growth category, rotational group at the end of treatment, annual Co-Gn increase and ANB variation of each patient.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Patient's age at T₀</th>
<th>Treatment length (Months)</th>
<th>Pre-treatment rotational group</th>
<th>Pre-treatment growth category</th>
<th>Post-treatment rotational group</th>
<th>Annual Co-Gn increase (mm)</th>
<th>ANB modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>36</td>
<td>A2D N</td>
<td>2</td>
<td>A1D DB</td>
<td>2.00</td>
<td>-3</td>
</tr>
<tr>
<td>2</td>
<td>11.2</td>
<td>36</td>
<td>A1D N</td>
<td>5</td>
<td>A1N DB</td>
<td>4.00</td>
<td>-6</td>
</tr>
<tr>
<td>3</td>
<td>11.3</td>
<td>31</td>
<td>R2D OB</td>
<td>3</td>
<td>R1N N</td>
<td>3.10</td>
<td>-4</td>
</tr>
<tr>
<td>4</td>
<td>11.8</td>
<td>30</td>
<td>R1N OB</td>
<td>4</td>
<td>R1N OB</td>
<td>3.20</td>
<td>-3</td>
</tr>
<tr>
<td>5</td>
<td>9.4</td>
<td>38</td>
<td>A2DDB</td>
<td>2</td>
<td>A1DDB</td>
<td>2.21</td>
<td>-3</td>
</tr>
<tr>
<td>6</td>
<td>10.9</td>
<td>29</td>
<td>R2D N</td>
<td>3</td>
<td>R1N N</td>
<td>2.90</td>
<td>-2</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>30</td>
<td>R1N OB</td>
<td>4</td>
<td>R1N N</td>
<td>3.60</td>
<td>-3</td>
</tr>
<tr>
<td>8</td>
<td>10.6</td>
<td>31</td>
<td>A1D DB</td>
<td>5</td>
<td>A1N DB</td>
<td>3.87</td>
<td>-4</td>
</tr>
<tr>
<td>9</td>
<td>12.2</td>
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<td>A1N OB</td>
<td>5</td>
<td>A1N N</td>
<td>4.00</td>
<td>-5</td>
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<tr>
<td>10</td>
<td>9.2</td>
<td>35</td>
<td>R2D N</td>
<td>3</td>
<td>R2D N</td>
<td>2.06</td>
<td>-3</td>
</tr>
<tr>
<td>11</td>
<td>11.7</td>
<td>29</td>
<td>R1N N</td>
<td>4</td>
<td>R1N N</td>
<td>2.90</td>
<td>-3</td>
</tr>
<tr>
<td>12</td>
<td>11.7</td>
<td>25</td>
<td>R2D N</td>
<td>3</td>
<td>R1N N</td>
<td>2.88</td>
<td>-4</td>
</tr>
<tr>
<td>13</td>
<td>10.3</td>
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<td>R1N OB</td>
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<td>R1N N</td>
<td>3.53</td>
<td>-4</td>
</tr>
<tr>
<td>14</td>
<td>11.5</td>
<td>26</td>
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<td>A1D N</td>
<td>3.69</td>
<td>-3</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>30</td>
<td>A2D DB</td>
<td>2</td>
<td>A1D DB</td>
<td>2.80</td>
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<tr>
<td>16</td>
<td>11.8</td>
<td>29</td>
<td>P1N OB</td>
<td>2</td>
<td>P1N N</td>
<td>2.07</td>
<td>-2</td>
</tr>
<tr>
<td>17</td>
<td>11</td>
<td>28</td>
<td>R1N N</td>
<td>4</td>
<td>R1N N</td>
<td>3.86</td>
<td>-3</td>
</tr>
<tr>
<td>18</td>
<td>11.3</td>
<td>29</td>
<td>R2D DB</td>
<td>3</td>
<td>R1N OB</td>
<td>3.72</td>
<td>-3</td>
</tr>
</tbody>
</table>

Table 2 – Annual Co-Gn average increases with standard deviations and C.I. in categories 2, 3, 4, 5 and in the whole sample.

<table>
<thead>
<tr>
<th>Category</th>
<th>Average annual Co-Gn increase</th>
<th>Standard deviation</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 2</td>
<td>2.27</td>
<td>0.36</td>
<td>0.36</td>
</tr>
<tr>
<td>Category 3</td>
<td>2.93</td>
<td>0.59</td>
<td>0.52</td>
</tr>
<tr>
<td>Category 4</td>
<td>3.42</td>
<td>0.37</td>
<td>0.33</td>
</tr>
<tr>
<td>Category 5</td>
<td>3.89</td>
<td>0.15</td>
<td>0.14</td>
</tr>
<tr>
<td>Whole sample</td>
<td>3.13</td>
<td>0.70</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Fig. 1 – Annual Co-Gn increases in the whole sample and in growth categories 2, 3, 4 and 5.

Fig. 2 – ANB modifications in the whole sample and in growth categories 2, 3, 4 and 5.

Table 3 – ANB modification with standard deviations and C.I. in categories 2, 3, 4, 5 and in the whole sample.

<table>
<thead>
<tr>
<th>Category</th>
<th>ANB modification</th>
<th>Standard deviation</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 2</td>
<td>-2.50</td>
<td>0.58</td>
<td>0.57</td>
</tr>
<tr>
<td>Category 3</td>
<td>-3.20</td>
<td>0.84</td>
<td>0.73</td>
</tr>
<tr>
<td>Category 4</td>
<td>-3.20</td>
<td>0.45</td>
<td>0.39</td>
</tr>
<tr>
<td>Category 5</td>
<td>-4.50</td>
<td>1.29</td>
<td>1.27</td>
</tr>
<tr>
<td>Whole sample</td>
<td>-3.33</td>
<td>1.03</td>
<td>0.32</td>
</tr>
</tbody>
</table>
4. Discussion

Many authors underlined the importance of a correct “timing” for the functional/orthodontic treatment.\textsuperscript{10-12} Some studies verified the efficacy of a late treatment, in a single phase and in permanent dentition, versus an early treatment, generally in two phases.\textsuperscript{35-40}

However, not much was written about individual response potential to treatment, although Petrovic showed six auxologic categories and suggested a method to know in advance a given patient’s growth potential.\textsuperscript{28-31}

Ahn\textsuperscript{33} touched on this subject and gave some factors which could reveal success possibilities of the Class II treatment.

The present study examined a sample, even if restricted and not homogenous, of functionally and orthodontic treated cases, trying to find a relation between Petrovic work and clinical experience.

A similar aim was in a study performed by Moro et al.,\textsuperscript{40} who assessed the different treatment response in patients belonging to auxologic categories 3 and 5.

Although the lack of a good statistic validation, present study results seems to indicate a relation between mandibular growth, expressed by CoGn increase and ANB angle decrease, and auxologic categories.

When auxologic category and its consequent growth potential increased, treatment produced a greater mandibular growth (Fig. 1) and a smaller sagittal skeletal discrepancy (Table 2).

These findings would confirm the smaller mandibular growth of a category 3 versus a category 5, as revealed by Moro et al.\textsuperscript{40}

If you compare the average CoGn increase of the whole sample to those ones detected by the Bolton Brush Study,\textsuperscript{41} the Burlington center\textsuperscript{42} and the Ann Arbor University\textsuperscript{43} in the same age ranges, treatment effect would seem mediocre or worthless.

Annual average CoGn increase (3.13 mm) of this study would result, in fact, similar to the average values of the above mentioned studies.

However the lack of an untreated control group and of national reference parameters prevents from obtaining valid scientific conclusions.

A few authors\textsuperscript{7,8,20,33}, on the other hand, verified functional appliance efficacy in producing skeletal modification with the aid of an untreated control group.

Moreover Chen, Will and Niederman,\textsuperscript{44} who performed a meta-analysis of growth values, detected an average CoGn increase of only 1.73 mm/year in untreated subjects.

As far as rotational modifications occurred with treatment, the general improvement, which the sample showed, agrees with Lavergne’s therapeutic objectives\textsuperscript{34} (Fig. 3).

The minimal rotational modifications, which had been observed, underline the impossibility to radically change patient’s facial type by means of orthodontic therapy. Therefore only a share of patients has the privilege to achieve ideal results.

Sometimes ideal targets cannot be obtained and therapy can produce only facial type improvement, but not total correction. When it occurs, the orthodontist can only plan
“limited” objectives, correcting the dental problem, or ask the orthognathic surgery support.

5. Conclusions

In the light of the acquired study results, gleams would open about the need to associate correct treatment time with treatment individualization, on the basis of auxologic categories and rotational type. This should permit treatment length reduction and avoid the useless search for results in patients who don’t respond to therapy because of uncorrected treatment time and/or unfavourable rotational type and growth category.

Rotational group detection, moreover, could reveal a reliable prognostic aid.

However longitudinal studies led according a rigorous scientific method and supported by statistic validation, are necessary to strengthen what came out of the present study.

Conflict of interest

The authors have reported no conflicts of interest.

Matériaux et méthodes: Dix-huit patients présentants une malocclusion de classe II (ANB ≥4°, classe dentaire II) ont été choisis et divisés en 4 groupes selon les catégories auxologiques. Le groupe de catégorie 2 a eu 4 patients, le groupe de catégorie 3 a eu 5, le groupe de catégorie 4 a eu 5 et, le groupe de catégorie 5 a eu 4, afin d’obtenir les courbes de croissance du patient et de détecter le temps correct de traitement, on a mesuré l’hauteur du patient tous les 3 mois. Cette méthode a été soutenue par la méthode vertébrale cervicale de maturation pour l’évaluation de la croissance mandibulaire. On a employé des élastiques et/ou d’appareils fonctionnels de classe II, pendant la phase fixe d’appareils, pour corriger des rapports squelettiques et dentaires. Le temps moyen de traitement était de 31 mois (groupe 28-36 mois). CoGn et ANB ont été détectés en traitement préparatoire et radiographies après traitement afin d’évaluer la croissance mandibulaire.

Résultats: La croissance la plus élevée était dans la catégorie 5, le plus basse dans la catégorie 2. On a généralement observé une amélioration différente avec le type de rotation.

Conclusions: Dans les patients prépubères dans classe II, le succès de traitement devrait dépendre pas seulement du choix d’appareils, de la capacité du clinicien et du temps correct de traitement, mais également de la croissance potentielle individuelle et du type facial. Par conséquent l’organigramme de Lavergne-Petrovic a pu devenir une grande aide diagnostique et pronostique pour l’orthodontiste.

Résumé

But: Le but est d’évaluer la croissance et la réponse mandibulaires au traitement fonctionnel dans les catégories auxologiques de Petrovic différentes et d’étudier l’utilité diagnostique et pronostique de l’organigramme de Lavergne-Petrovic.

REFERENCES


Conflict of interest

The authors have reported no conflicts of interest.

Resumen

Objetivo: Evaluar el crecimiento mandibular y la respuesta al tratamiento funcional en diferentes categorías auxológicas de Petrovic, para investigar la utilidad de diagnóstico y pronóstico del diagrama de flujo de Lavergne-Petrovic.

Materiales y métodos: Fueron seleccionados dieciocho pacientes con maloclusión de clase II (ANB ≥4°) divididos en 4 grupos de acuerdo a las categorías auxológicas. En la categoría del 2 grupo fueron analizados 4 pacientes, en la categoría del grupo 3 fueron analizados 4 pacientes. Con el fin de obtener las curvas de crecimiento de los pacientes y detectar el tiempo de tratamiento correcto, se midió la altura del paciente cada 3 meses. Este método fue soportado mediante el método de “maduración vertebral cervical” para de esta forma evaluar el crecimiento mandibular. Se utiliza para corregir los problemas esqueléticos con aparato funcional y dentales con elásticos de Clase II y aparatos fijos. El tiempo de tratamiento promedio fue de 31 meses (rango 28-36 meses). Los puntos CoGn y ANB fueron analizados en fase (pre-tratamiento y post-tratamiento) mediante radiografías con el fin de evaluar el crecimiento mandibular.

Resultados: El mayor crecimiento fue obtenido en la categoría 5, el menor en la categoría 2. Se observó una mejoría del tipo de rotación en general.

Conclusiones: En pacientes prepuberales con clase II, el éxito del tratamiento no solo se debe al tipo de aparato, a la manualidad del clinico y al tiempo de tratamiento correcto, si no pero también en el crecimiento potencial de cada tipo y facial. Por lo tanto Lavergne diagrama de flujo de Petrovic podría convertirse en una ayuda diagnóstica y pronóstico para el ortodoncista.

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