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Cephalometric Evaluation of Maxillary Incisors Torque and Vertical Changes Utilizing Standard Edgewise Mechanics

Evaluación Cefalométrica del Par de Torsión y Cambios Verticales en el Incisivo Maxilar Utilizando Mecánicas Edgewise Estándar

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ABSTRACT: In 1995 Gebeck & Merrifield studied a successful and unsuccessful treated Class I and Class II's samples; they found a -1.33 mm intrusion in the former and a 0.80 mm extrusion in the latter. The purpose of this article was to perform a cephalometric evaluation of maxillary incisors torque and vertical changes. We studied a sample of 129 patients, 30 males and 99 females, taken from The Charles H. Tweed Foundation Long Term Study, at pretreatment mean age 12.93 years, posttreatment mean age 16.19 years and follow up post retention mean age 29.83 years, a 13.88 years interval. The records were collected from private practitioners across the North American continent who used Standard Edgewise Mechanics and were members of the Charles H. Tweed Foundation. All patients were Class I and II American whites treated with the extraction of 4 premolars. We found an Upper anterior incisal edge to PP vertical linear measurement 28.7 and 29.2 mm, +0.53 mm ($p<0.019$) from pretreatment to posttreatment. The average Upper 1 to SN angle was 103.2° at pretreatment and 100.1° at posttreatment, -3.2° ($p<0.000$), Upper 1 to PP 111.0° and 108.9°, -2.2° ($p<0.000$), the three of them statistically significant. Conversely, Upper 1 to commissure was not. The four measurements were also statistically significant posttreatment to follow up, upper anteriors kept losing torque after posttreatment, and less upper anteriors surface was below the commissure. Some torque loss and vertical extrusion can be expected while treating patients with extractions of four premolars, therefore, upper incisor inclination increase and vertical change by itself cannot determine the success of treatment.

KEY WORDS: Orthodontics, incisor torque, extraction, cephalometric.

INTRODUCTION

Angle developed orthodontics as a specialty, with himself as the "father of modern orthodontics." His classification of malocclusion in the 1890s (6th edition) was an important step in the development of orthodontics and a normal occlusion (Proffit, 1993). By early 1900s orthodontics evolved int the treatment of malocclusion, defined as any deviation from the ideal occlusal scheme described by Angle. Since precisely defined relationships required a full complement of teeth in both arches, maintaining an intact dentition became an important goal of orthodontic treatment. Angle and his followers strongly opposed extraction for orthodontic purposes. As the disciples of a perceived prophet are often more religious than the master, it is not hard to understand how the battle lines came to be drawn and, in retrospect to see how the battle would eventually evolve (Bernstein, 1992). With the emphasis on dental occlusion that followed, however less attention came to be paid to facial proportions and esthetics.

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In 1902 article, Angle (1902) set forth his line of reasoning toward the development of his treatment philosophy. In this article he recounted his conversations with his friend, the artist Edmund Wuerpel (1931) whose help led to his concepts for facial beauty and harmony. Earlier, in 1887, Angle (1887) wrote on his new system to regulate and retain the teeth. The first edition of Angle's book was published. Other editions supposedly followed up to 1897 first edition, when the fifth edition (Angle, 1887) expanded in scope, came out. This was followed by the enigmatic sixth edition (Angle, 1900), which was supposedly withdrawn by Angle from publication. This sixth edition, which has never been referred to previously in the literature as far as Bernstein (1992a) was concerned. As a matter of fact, Graber said that "He had not as yet come across Bernstein article that makes reference to the sixth edition." What is unique about the sixth edition is that it contains an enormous amount of material and case reports in which the extraction of teeth was involved to solve orthodontic treatment problems. Why did Angle never referred to this book? Why did he supposedly have it withdrawn from publication? (Bernstein, 1992b). "It was because of his idealism, because of his insatiable desire to live on the heights, and because he required this of himself, he required it of all mankind (Wuerpel, 1931)."

In orthodontics, the first root movement (torque) was introduced in 1893 by C. S. Case, and it took 34 years for E. H. Angle to develop the edgewise appliance. In 1927, Tweed took the Angle course conducted by George Hahn in Berkeley, California, and then spent six weeks with Dr. Angle in Pasadena. He convinced Tweed that the status of orthodontics needed to be improved. In preparation for this, he decided that it was necessary to perfect his own clinical effectiveness by solving the requirements of excellent facial esthetics and more stable results of therapy. Analysis of previous treatment results, led him to retreat, without fee some 300 children to reduce the bimaxillary occlusions previously produced. Through this study, he perfected to his own satisfaction a technique of space closure following extraction of four first premolars as well as a better relationship of teeth to basal bone of the jaws an improved facial esthetics (Higley, 1960).

Gebeck & Merrifield (1995) studied a successful and unsuccessful treated Class I and Class II's samples, they concluded that orthodontic mechanics influences the dynamic development of skeletal and dental relationships. Direction of growth can be influenced to deviate from the normal course of development. Such deviations can be positive or negative relative to specific treatment objectives. Therefore, it becomes imperative that diagnostic and treatment efforts be constantly refined to produce more consistent positive effects. Maxillary incisor directional control is a key of success in the successful group. Conversely, in his study with unsuccessfully treated malocclusion sample, of significance was the fact that the maxillary incisor could not be intruded because of the additive effect of multiple directional changes not found to be in harmony with the normal growth response. This in turn produced an excessive increase of anterior facial height in its proportion to posterior facial height, it had the effect of increasing facial convexity and was the single most important factor that placed patients in the unsuccessful treatment sample.

Therefore, the purpose of this investigation, a comparison of 129 patients from pretreatment to posttreatment, and posttreatment to follow up, was to perform a cephalometric evaluation of maxillary incisors torque and vertical changes; it answers the research question: What are the maxillary incisors torque and vertical changes utilizing standard Edgewise mechanics (SEM) at posttreatment, and long-term, at least 10 years follow-up. It tests the null hypothesis that SEM affects maxillary incisors torque and vertical changes.

MATERIAL AND METHOD

In this study we included 129 Class I and Class II cases of the original data from 236 long-term recall study cases received by Dr. George S. Harris (Menominee, Michigan) and Dr. James L. Ferguson (Franklin, Tennessee) (Table I), from the Tweed Foundation (TF) Long Term Study (LTS). The records were collected from private practitioners across the North American continent who used (SEM) and were members of the TF. With financial support from, the TF, the Research Committee was formed. The goal of the committee was to have every member provide ten sets of records, including pretreatment, retention, and 10-year post-treatment recall records. Members were asked to submit records of cases that were a minimum of 10 years out of treatment, regardless of treatment outcome. This would allow the establishment of a broad-based sample to describe the quality of the cases and to allow members to learn from treatment failures as well as successes.

Table I Angle´s molar relation.

Angle Class	N	%
I	37	28.7
II	92	71.3
Total	129	100.0

Boley (2007) suggested that, "Perhaps the best sample in the literature is one in which every patient was treated in the same manner." With the submission of cases by multiple practitioners, the influence of individual practitioner biases and treatment prejudices is diminished. It is the intent of the research to be based on a representative sample of patients. It is thought that practitioners could not be too discriminatory, because in reality, there is not a great availability of records at 10 or more years out of treatment. The present study intended to provide insight into the posttreatment and follow-up (long-term) of treated patients. The nature of the present Tweed sample LTS is (a) that cases were evaluated long-term (>10 years) after posttreatment, (b) cases were treated in private practice, and (c) all cases were treated using SEM.

All patients were American whites. There were 37 Class I and 92 Class II cases (Table I), 30 males and 99 females. The present sample records were available at three-time intervals for each patient: The criteria for inclusion in the study were that all subjects had pretreatment, posttreatment, and follow up long-term records. They were taken at pretreatment records 12.93 years, banding mean age 13.79 years, debanding mean age 15.92 years, posttreatment records mean age 16.19 years, and follow up long-term posttreatment recall examination records mean age 29.80 years, 13.88 years interval (Table II). Each subject was included in the study because of the availability of complete records. All individuals had received comprehensive orthodontic treatment and the extraction of 4 premolars as part of their treatment. Patients treated without premolar extractions were not included in the sample. Cephalometric tracings from pretreatment, posttreatment, and follow up were available. These cephalograms were digitized and measured by Donna Niemczyk with guidance from George Harris and James Ferguson using Dentofacial Planner® version 32; (Dentofacial Software, Toronto, Ontario, Canada). This software was well-suited for data acquisition, but the program had not been upgraded and is not compatible with current operating systems (specifically, OS 10). The work initiated by Dr. George S. Harris and Dr. James L. Ferguson has been preserved and upgraded by the senior author.

Standard Edgewise Mechanics. Ideally SEM patients are treated with a nontorqued, nonangulated or variations in thickness of the bracket or slot. All slots are 0.022" x 0.028" in dimension and are placed so that they are at right angles to the long axes of the teeth. In this technique the maxillary and mandibular arches were leveled and aligned, and after canine retraction had been completed in both arches, 0.020 X 0.025-in maxillary and 0.019X.025 mandibular closing-loop archwires were inserted. High-pull J-hook headgear force (recommended for approximately 10-12 hours per day) was applied to hooks soldered to the archwire between the maxillary central and lateral incisors. After mandibular space closure, mandibular anchorage usually was prepared, and the patients were instructed to wear the mandibular high-pull headgear against hooks soldered mesially to the canines on the mandibular archwire. A mandibular stabilizing archwire was then placed, and Class II elastics, anterior vertical elastics, and a high-pull "J"-hook headgear to the maxillary archwire were placed. The intraoral elastics were prescribed to be worn 24 hours a day during this treatment phase. Teeth were retained with maxillary and mandibular Hawley retainers (Merrifield, 1986; Vaden *et al*., 1994).

Cephalometric Analysis. Perhaps the most commonly used measure of upper incisor inclination

Table II Descriptive statistics for chronologic ages at banding age and pretreatment records; debanding age and posttreatment records; follow up records.

Variables (N=129)	Range	Minimum	Maximum	Mean	SD
Banding- age	29.0	7.1	36.1	13.76	3.69
Debanding-age	29.7	9.1	38.9	15.92	3.74
Pretreatment records age	28.7	6.9	35.6	12.93	3.91
Posttreatment records -age	29.45	9.46	38.91	16.19	3.71
Follow-up records age	30.11	17.62	47.73	29.80	5.99
Banding to debanding treatment time (years)	4.06	0.83	4.88	2.15	0.61
Pretreatment to posttreatment records time (years)	5.01	0.00	5.01	2.42	0.76
Posttreatment to follow-up records (years)	24.2	2.5	26.7	13.88	4.93

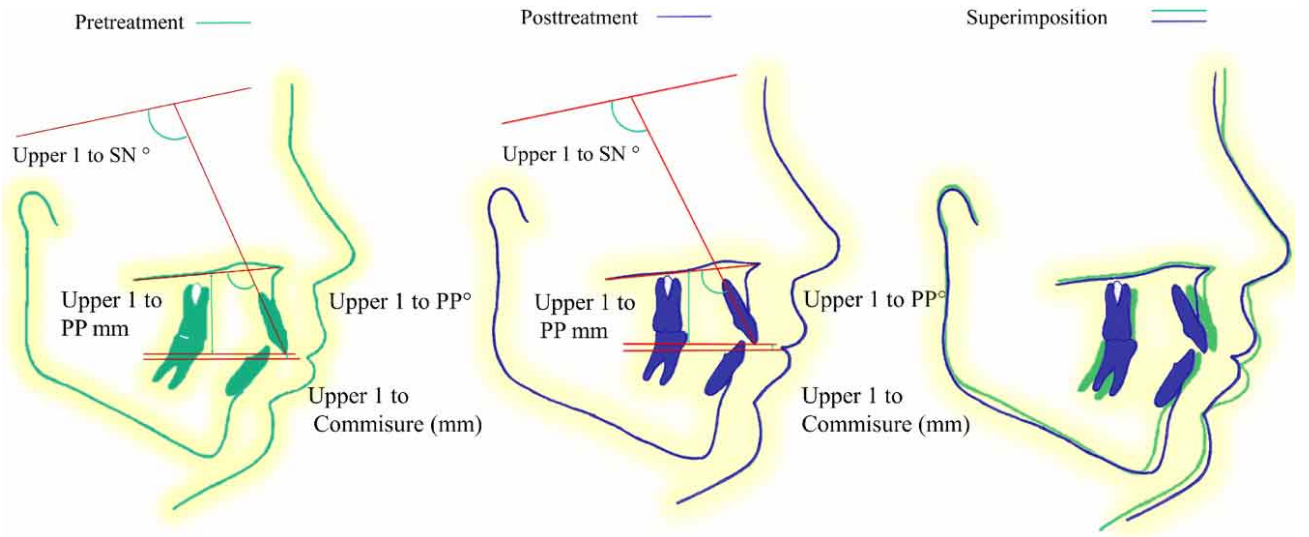

Fig. 1. Cephalometric tracing at pretreatment, posttreatment and superimposition.

in the literature is Upper 1 to SN. Therefore, for this study we traced and measured (Fig. 1) upper maxillary incisor plane to Sella-Nasion plane (U1-SN), upper maxillary incisor plane to palatal plane (U1-PP), upper maxillary incisor tip to palatal plane measured perpendicularly (U1-PP mm), and upper maxillary incisor tip to commissure measured perpendicularly to PP (U1-Commissure mm).

Statistical analysis. Statiscal analysis was carried out using SPSS version 15.0 (Statistical Package for the Social Sciences, version 15.0, SPSS, Inc., Chicago, IL). Descriptive statistics (means and standard deviations) were calculated for each variable. An independent sample t test was used; significant levels were set at 5 % level ($p<0.05$).

RESULTS

Descriptive statistics for changes, means and standard deviations including minimum and maximum for the changes in various dimensions are summarized in Tables II to V.

The average Upper 1 to SN angle was 103.2° at pretreatment and 100.1°, a -3.2° ($p<0.000$) at posttreatment, Upper 1 to PP 111°.0 and 108.9°, a -2.2° ($p<0.000$), Upper anterior incisal edge to PP vertical linear measurement 28.73 and 29.26 mm, a 0.53 mm ($p<0.019$) (Fig. 2), the three of them statistically significant, whereas Upper 1 to commissure was not (Table IV).

Table III Descriptive Statistics for upper incisor torque and vertical distance variables.

Variables (N=129)	Range	Minimum	Maximum	Mean	SD
Pretreatment Upper 1 To SN°	38	82	120	103.29	7.32
Pretreatment Upper 1 To PP°	38	92	130	111.06	7.13
Pretreatment Upper 1 To PP mm	16.8	21.3	38.1	28.73	2.97
Pretreatment Upper 1 To Commissure mm	12	-1	11	3.56	2.09
Posttreatment Upper 1 To SN°	34	83	117	100.17	6.14
Posttreatment Upper 1 To PP°	39	92	131	108.95	7.14
Posttreatment Upper 1 To PP mm	15.10	23.00	38.10	29.26	3.11
Posttreatment Upper 1 To Commissure mm	8.50	-0.40	8.10	3.48	1.51
Follow-up Upper 1 To SN°	40	78	118	98.92	6.44
Follow-up Upper 1 To PP°	37	90	127	107.18	7.06
Follow-up Upper 1 To PP mm	16.70	22.40	39.10	30.38	3.48
Follow-up Upper 1 To Commissure mm	8.50	-0.90	7.60	3.18	1.73

The four measurements were also statistically significant posttreatment to follow up (Table V), upper anteriors kept losing torque after posttreatment, and less upper anteriors surface was below the commissure. We know that less upper anterior teeth surface shows with aging.

Table IV. Descriptive statistics for upper incisor torque and vertical distances at pretreatment and posttreatment records.

Upper incisor torque and vertical distance	Pretreatment		Posttreatment		t
	Mean	SD	Mean	SD	
Upper 1 To SN°	103.29	7.32	100.17	6.14	0.000
Upper 1 To PP°	111.06	7.13	108.95	7.14	0.004
Upper 1 To PP mm	28.73	2.97	29.26	3.11	0.019
Upper 1 To Commissure	3.56	2.09	3.48	1.51	0.662

*Paired test p<0.05

Table V. Descriptive statistics for upper incisor torque and vertical distance at posttreatment and follow-up.

Upper incisor torque and vertical distance	Posttreatment		Follow-up		t
	Mean	SD	Mean	SD	
Upper 1 To SN°	100.17	6.14	98.92	6.44	0.006
Upper 1 To PP°	108.95	7.14	107.18	7.06	0.001
Upper 1 To PP (mm)	29.26	3.11	30.38	3.48	0.000
Upper 1 To Commisure	3.48	1.51	3.18	1.73	0.007

*Paired test p<0.05

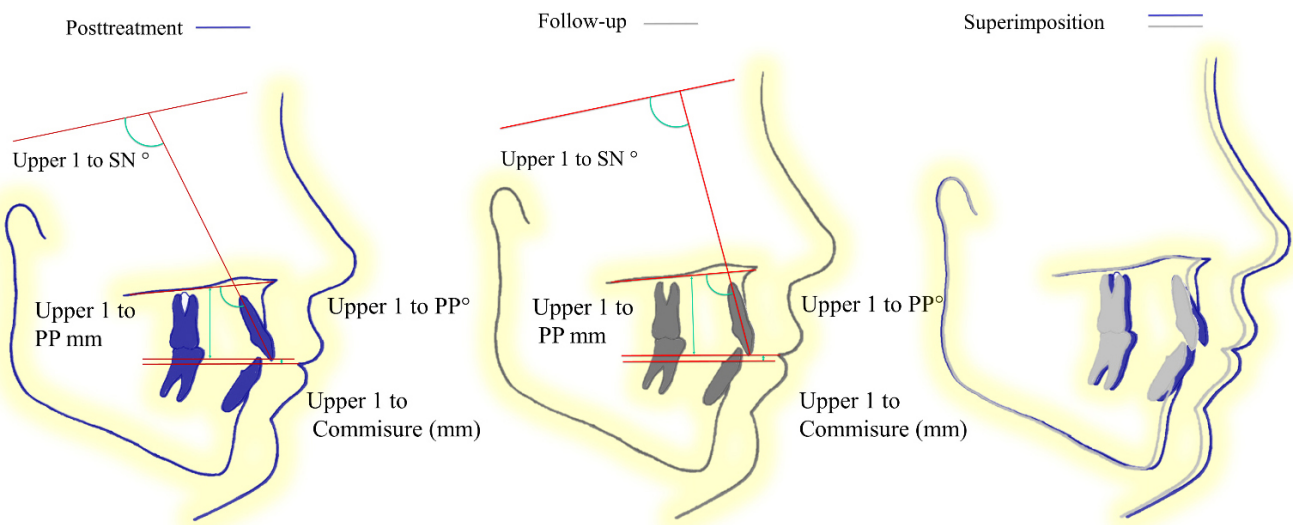

Fig. 2. Cephalometric tracing at posttreatment, follow-up and superimposition.

DISCUSSION

This study is relevant and important because having proper torque inclination of the anterior teeth is critical for successful treatment (Gebeck & Merrifield, 1995). They studied a successful and unsuccessful of treated Class I and Class II's samples, they concluded that orthodontic mechanics influences the dynamic development of skeletal and dental relationships; maxillary incisor directional control is a key of success in the successful group. Conversely, in their unsuccessful sample of significance was the fact that the maxillary incisor could not be intruded because of the additive effect of multiple directional changes not found to be in harmony with the normal growth response.

We hope that our study will give our specialty some useful and important information about the long-term impact of directional forces on maxillary incisor

torque behavior. We chose the measure of upper incisor inclination to SN, as it is the most commonly used in the literature.

The results of the present study differ from those of the Gebeck & Merrifield (1995), they reported that the maxillary incisor was intruded 0.99 mm while being retracted, whereas we found a 0.53 mm extrusion ($p<0.019$) from pretreatment to posttreatment; It came in shock to our expected result, we had hoped for a similar intrusion.

Park *et al*. (2008) compared treatment effects and anchorage potential of sliding mechanics with titanium screws on en-masse retraction of 6 anterior teeth to anchorage, with the Tweed-Merrifield technique, which requires patient compliance with high-pull J- hook. Park *et al*. (2008) study found a 0.87 mm ($p<0.1196$) extrusion in the Tweed group and a -0.18 mm ($p<0.5705$) intrusion in his titanium screws on en-masse retraction of 6 anterior teeth. Moreover, maxillary incisors tipped lingually in his titanium screws on en-masse retraction 19.29° ($p<0.001$) whereas in our study Upper 1 to SN lost -3.2° only ($p<0.000$).

A Saint Louis University thesis, Jamison (2014) compared 30 adolescent Caucasian Class II division 1 patients treated with four bicuspid exactions using the Tweed-Merrifield approach with a similar 30 patients sample treated with pre-angulated, self-ligation, Roth prescription appliance with Retranol© archwires and sliding mechanics; noteworthy is that the latter sample used headgear and, temporary anchorage mini-screws. Jamison's results showed that Upper 1 to SN was increased 2.7° in the Retranol sample as compared to a -4.2° decrease in the standard group. They claimed that the former showed significantly more upper incisor inclination than the standard edgewise group at the end of treatment; vertically the latter sample (standard edgewise) showed a +2.7 mm extrusion while the former (Retranol© sample) a +1.6 mm increase; all those measurements reported pretreatment and posttreatment means, but did not gave statistical significance comparing each other.

Probably the "gold standard" to measure up our study to is Luppanapornlarp & Johnston Jr. (1993) "clear-cut" Class II patients and Paquette *et al*. (1992) "borderline" Class II-1 patients; both samples consisted of 33 patients. Pretreatment to posttreatment in the former "clear-cut" extraction patients, Upper 1 to SN diminished from 104.3 to 99.7 a -4.6° loss compared to our- 3.2° ($p<0.000$), in the latter "borderline" Class II-1 extraction patients, they reported an Upper 1 to SN loss of 8.2° posttreatment compared to ours 3.2°; a linear Upper tip to PP was not available in either.

U1 to SN posttreatment to follow up changes, 13.88 years in ours, 15.3 years in Luppanapornlarp & Johnston Jr. (1993), and 14.5 years in Paquette *et al*. (1992), was a -1.2° in ours versus -2.1° in "clear-cut" Luppanapornlarp & Johnston Jr. (1993) and -0.6° in Paquette *et al*. (1992) "borderline" patients.

CONCLUSION

Given the level of coincidence of our study with those of Luppanapornlarp & Johnston Jr. (1993), and Paquette *et al*. (1992), despite our larger sample 129 patients, we conclude that some torque loss and vertical extrusion can be expected while treating patient's pretreatment to posttreatment with extractions of four premolars; posttreatment to follow up keep diminishing as well although to a lesser scale. Therefore, upper incisor inclination increases and vertical change by itself cannot determine the success of treatment.

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RESUMEN: En 1995, Gebeck y Merrifield estudiaron muestras de Clase I y Clase II tratadas con éxito y sin éxito; encontraron una intrusión de -1,33 mm en el primero y una extrusión de 0,80 mm en el segundo. El propósito de este artículo fue realizar una evaluación cefalométrica del torque y los cambios verticales de los incisivos maxilares. Estudiamos una muestra de 129 pacientes, 30 hombres y 99 mujeres, tomados del estudio a largo plazo de la Fundación Charles H. Tweed, con una edad media previa al tratamiento de 12,93 años, una edad media posterior al tratamiento de 16,19 años y una edad media de seguimiento posterior a la retención de 29,83 años, con un intervalo de de 13,88 años. Los registros se recopilaron de médicos privados en todo el continente norteamericano que utilizaron Standard Edgewise Mechanics y eran miembros de la Fundación Charles H. Tweed. Todos los pacientes eran blancos americanos Clase I y II tratados con extracción de 4 premolares. Encontramos una medida lineal vertical del borde incisal anterior superior a PP de 28,7 y 29,2 mm, +0,53 mm ($p<0,019$) desde el pretratamiento hasta el postratamiento. El promedio del ángulo Superior 1 a SN fue de 103,2° en el pretratamiento y 100,1° en el postratamiento,

-3,2° (p<0,000), Superior 1 a PP 111,0° y 108,9°, -2,2° (p<0,000), los tres estadísticamente significante. Por el contrario, Superior 1 a la comisura no lo era. Las cuatro mediciones también fueron estadísticamente significativas para el seguimiento después del tratamiento, los dientes anteriores superiores siguieron perdiendo torsión después del tratamiento y se observó menor superficie de los dientes anteriores superiores debajo de la comisura. Se puede esperar cierta pérdida de torque y extrusión vertical al tratar a pacientes con extracciones de cuatro premolares, por lo tanto, el aumento de la inclinación del incisivo superior y el cambio vertical por sí mismos no pueden determinar el éxito del tratamiento.

PALABRAS CLAVE: Ortodoncia, torque incisivo, exodoncia, cefalometría.

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