

Original research

# The influence of pre-surgical orthodontic treatment on the dento-skeletal profile of Class III patients



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ABSTRACT

**Objectives:** This cephalometric study intended to evaluate pre-surgical changes in cephalometric variables on the lower third of the face produced by the orthodontic treatment, in patients with severe Class III malocclusions.

**Methods:** The sample included 40 adults, divided into three groups: no-extractions (N), extractions for orthodontic reasons (E), and previous extractions for non-orthodontic reasons (E-NO). Student t-tests were used to evaluate the influence of orthodontic treatment on the cephalometric variables. An ANOVA was used for group comparisons before treatment and to compare the changes produced by the orthodontic treatment in the three groups. The significance level was established at 5%.

**Results:** In Group E, significant ( $p < 0.05$ ) retraction and retroclination of the upper incisors were observed. The lower incisors proclined in all the three groups and protracted in Groups N and E-NO. The upper incisor remained proclined in Group N, and the lower incisor retroclined in Group E-NO. There was a clockwise rotation of the mandible, with an increase in total and inferior facial heights, in both the extraction groups. The upper molars advanced in all groups.

**Conclusions:** 1) The SNA angle decreased due to point A retraction in Group E. 2) Mandibular clockwise rotation led to increased total and inferior facial heights, in both the extraction groups. 3) Extractions facilitated incisor decompensation in Group E. 4) After treatment, the lower incisors remained retroclined in Group E-NO, due to an exaggerated initial retroclination. (Rev Port Estomatol Med Dent Cir Maxilofac. 2020;61(1):2-9)

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## A influência do tratamento ortodôntico pré-cirúrgico no perfil dento-esquelético de indivíduos com Classe III

### R E S U M O

#### Palavras-chave:

Má oclusão de Classe III  
Cefalometria  
Tratamento ortodôntico pré-cirúrgico

**Objetivos:** Este estudo cefalométrico pretendeu avaliar as alterações produzidas pelo tratamento ortodôntico pré-cirúrgico sobre as variáveis cefalométricas dento-esqueléticas do terço inferior da face, em pacientes com maloclusões severas de Classe III.

**Métodos:** A amostra, constituída por 40 adultos, foi dividida em três grupos: sem extrações (N); extrações por razões ortodônticas (E); dentes previamente extraídos por razões não ortodônticas (E-NO). A influência do tratamento ortodôntico sobre as medições, bem como as diferenças iniciais entre grupos, foram determinadas utilizando testes t de Student. Para efetuar a comparação entre os três grupos, foi utilizada uma análise ANOVA. O nível de significância estatística foi estabelecido em 5%.

**Resultados:** No Grupo E, os incisivos superiores foram significativamente ( $p < 0,05$ ) retraídos e retro-inclinados. Verificou-se uma proinclinação do incisivo inferior nos três grupos e ainda um avanço nos grupos N e E-NO. O incisivo superior permaneceu proinclinado no Grupo N e o incisivo inferior continuou retro-inclinado no Grupo E-NO. Foi observada uma rotação horária da mandíbula, com aumento da altura facial total e inferior, nos grupos E e E-NO. O molar superior mesializou nos três grupos.

**Conclusões:** 1) O ângulo SNA diminuiu no Grupo E à custa da retração do ponto A. 2) Observou-se uma rotação horária da mandíbula com aumento da altura facial total e inferior nos grupos com extrações. 3) As extrações permitiram uma maior descompensação dos incisivos no Grupo E. 4) No Grupo E-NO, os incisivos inferiores continuaram retro-inclinados depois do tratamento, uma vez que a retro-inclinação inicial era excessiva. (Rev Port Estomatol Med Dent Cir Maxilofac. 2020;61(1):2-9)

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## Introduction

A large percentage of individuals seeking a combined orthodontic/orthognathic surgery intervention have skeletal Class III malocclusions.<sup>1</sup> This sagittal discrepancy is characterized by maxillary deficiency, mandibular excess or a combination of both.<sup>1,2</sup> Changes in vertical facial growth can further contribute to the complexity of these cases.<sup>3-7</sup>

There are several treatment options for Class III malocclusions. Dentofacial orthopedic appliances<sup>8-10</sup> and devices for protraction with bone anchorage<sup>11,12</sup> can improve the growth pattern in children with a genetic predisposition for this problem. Purely orthodontic dentoalveolar compensation can be attempted to camouflage the skeletal discrepancy in adults when an aesthetically acceptable profile accompanies a mild-to-moderate skeletal Class III malocclusion.<sup>13-16</sup>

Excessive retroclination of the lower incisors during camouflage treatments can lead to an exaggerated buccal prominence of their roots and gingival recession.<sup>14</sup> In such cases, a combined surgical orthodontic treatment, rather than camouflage, would be the correct approach.<sup>14</sup> Additional guidelines for surgical orthodontic treatment in adult patients are ANB and lower incisor-mandibular plane angles smaller than  $-4^\circ$  and  $83^\circ$ , respectively.<sup>17</sup> Other important factors that distinguish surgical from non-surgical patients are the ratio between maxillary and mandibular

length, the gonial angle, the sella-nasion distance and the Wits appraisal.<sup>16-19</sup>

The main objectives of orthognathic surgery are the development of a functional and stable occlusion and an improvement in facial aesthetics.<sup>15,20-25</sup> In this type of treatment, a pre-surgical orthodontics phase is usually followed by the surgical correction of the skeletal discrepancy. Then, a post-surgical orthodontic period is required to finish and detail the occlusion.<sup>26</sup>

Dento-alveolar compensations in the form of upper incisor proclination and lower incisor retroclination help to maintain function and camouflage an existing Class III skeletal discrepancy.<sup>4,15,27,28</sup> In patients with larger anteroposterior discrepancies and increased mandibular posterior rotation, the compensatory lower incisor retroclination is increased.<sup>13,28</sup> Additionally, in hyperdivergent patients, the lower incisors erupt in a way that maintains the overbite, and the alveolar bone becomes longer and thinner in the labio-lingual direction. These features may increase the risk of periodontal problems in the anteroinferior region.<sup>27,29,30</sup> Pre-surgical orthodontics eliminates these compensations by creating or increasing a reverse overjet, which allows a surgical mandibular setback and/or maxillary advancement. As a result, the direction of the incisor movement is opposite to that required by a non-surgical, compensatory treatment plan. Therefore, comparing to the baseline, the patient's malocclusion and profile are generally

worse immediately before surgery, and this can only be avoided if an early surgical approach is used.<sup>15,31,32</sup>

Depending on the magnitude of the initial sagittal discrepancy and the degree of incisor compensation observed, an orthodontic treatment plan is established. This treatment may require the extraction of upper first premolars, alone or in combination with the lower second premolars.

The aim of this retrospective cephalometric study was to evaluate the changes produced by pre-surgical orthodontic treatment on dental and skeletal measurements of the lower third of the face, in patients with skeletal Class III malocclusions requiring orthognathic surgery, using different extraction protocols. The null hypothesis tested was that, after the pre-surgical orthodontic phase, no differences would be found in cephalometric measurements between the extractions (for orthodontic and non-orthodontic reasons) and the no-extractions groups.

## Material and methods

The sample for this study consisted of adult orthodontic patients with skeletal Class III malocclusions requiring orthognathic surgery. The inclusion criteria were European origin, no previous orthodontic or orthopedic treatments, good quality cephalometric x-rays, and treatment performed by the same specialist in orthodontics. After approval by the Ethics Committee of the School of Dentistry of the University of Lisbon, a sample of 18 males and 22 females was gathered, with informed consent. Individuals with congenital anomalies and severe facial asymmetries were excluded from the study.

The original sample was divided into three groups: Group N, including no extractions (n =13); Group E, including upper first premolars extracted for orthodontic treatment purposes

(n =12); and Group E-NO, including previous extractions for non-orthodontic reasons (n =15).

Lateral cephalograms were taken before (T1) and after (T2) the pre-surgical orthodontic treatment phase with the aid of a cephalostat and with the Frankfurt horizontal plane parallel to the floor. The Adobe Photoshop CS5 (Adobe Inc.® San José, California) program was used to superimpose the T2 cephalogram on the T1 one, according to the structural method of Björk. The horizontal reference plane (x) was constructed 7° above the sella-nasion line, with the vertex at nasion.<sup>33</sup> A line perpendicular to the horizontal plane at nasion was used as the vertical reference plane (y). All linear cephalometric variables were measured either parallel or perpendicular to the x plane, using the cephalometric program Nemoceph (Nemotec®, Madrid, Spain). The cephalometric landmarks used are described in Table 1. The palatal plane (ANS-PNS), the mandibular plane (Tgo-Me), the long axis of the upper incisor UI1 (UI-UIA) and the long axis of the lower incisor LI1 (LI-LIA) were also traced in the analysis.

Cephalometric measurements were chosen to represent skeletal and dental variables, which could be changed by the pre-surgical orthodontic treatment. For skeletal changes, the SNA angle, total facial height (TFH, N-Me distance), inferior facial height (IFH, Sp'-Me distance), maxillary prominence (point A to y distance), mandibular prominence (point B to y distance), chin prominence (Pg to y plane) and the MP-x angle (Tgo-Me to x plane) were calculated. For dental changes, the following measurements were evaluated: upper incisor exposure (UI-Stms distance), overjet, overbite, UI-y distance, LI-y distance, UI-PP distance, LI-MP distance, UI1-x angle, LI1-x angle, UI1-PP angle, LI1-MP angle, Um-y distance, Lm-y distance, Um-PP distance, and Lm-MP distance.

One researcher traced all the radiographs and was blinded for patients' identity, to avoid bias. Ten randomly chosen cases

**Table 1. Cephalometric landmarks traced**

Nasion (N)	The most anterior point on the frontonasal suture
Sella (S)	The midpoint on the cavity of sella turcica
Articulare (Ar)	The intersection of the posterior surface of the mandibular condyle with the cranial base
Nasal spine (Sp')	The intersection of the N-Me line and the palatal plane
Anterior nasal spine (ANS)	The most anterior point of the nasal spine
Posterior nasal spine (PNS)	The most posterior point of the hard palate
A point	The deepest point on the anterior contour of the maxilla
B point	The deepest point on the anterior contour of the mandible
Pogonion (Pg)	The most anterior point on the osseous contour of the chin
Menton (Me)	The most inferior point on the osseous contour of the chin
Gonion (Tgo)	The intersection of the mandibular plane with the posterior ramus plane
Upper incisor (UI)	The incisal tip of the most anterior maxillary incisor
Lower incisor (LI)	The incisal tip of the most anterior mandibular incisor
Upper incisor apex (UIA)	The root apex of the most anterior maxillary incisor
Lower incisor apex (LIA)	The root apex of the most anterior mandibular incisor
Upper first molar (Um)	The midpoint of the mesiobuccal cusp of the maxillary first molar
Lower first molar (Lm)	The midpoint of the mesiobuccal cusp of the mandibular first molar
Stomium superius (Stms)	The lowermost point of the upper lip

were re-traced within a month interval, by the same investigator. Method error was evaluated with paired t-tests and the Dahlberg's equation:  $\sqrt{\sum d^2/2n}$ , where d is the difference between the calculated values between the first and the second tracings.<sup>34</sup>

Statistical analysis was done with SPSS® version 20.0 for Macintosh (IBM Company, Armonk, NY, USA). Descriptive statistics (mean and standard deviation) were calculated at T1 and T2 for each cephalometric variable. The Shapiro-Wilk test was performed to evaluate normality in the sample distribution. A t-test for independent samples was used to determine the influence of the orthodontic treatment on the cephalometric variables within each group. Differences between the groups before treatment and differences in the changes produced by the orthodontic treatment in the three groups were evaluated using an ANOVA analysis. Post-hoc testing was done with the Bonferroni method. The level of statistical significance was fixed at 5%.

For the method error, the paired t-test revealed no significant differences between the first and the second measurements ( $p>0.05$ ). No systematic deviations were found, and the values obtained from the Dahlberg equation were generally small ( $<1^\circ/1\text{mm}$ ). Therefore, there were no significant random errors.

## Results

According to the results of the Shapiro-Wilk test, all variables in the study showed normal distribution. The descriptive statistics (mean and standard deviation) before the orthodontic treatment (T1) are presented in Table 2.

The differences between Groups N, E and E-NO before the pre-surgical orthodontic treatment (T1) are exposed in Table 2. In comparison with Group N, Group E was characterized by a decrease in TFH and IFH. The distances UI-PP, Um-PP, LI-MP and Lm-MP were also reduced. The distance Lm-MP was smaller in Group E-NO than in Group N. Upper incisor inclination in relation to both the palatal plane and the horizontal plane was reduced in Group E-NO in comparison with the other two groups. The lower incisor retroclination was significantly ( $p<0.05$ ) greater in Group E-NO than in Group E.

Changes produced by the orthodontic treatment are presented in Table 3 for Group N, Table IV for Group E and Table V for Group E-NO. In Group N, the overjet became more negative due to lower incisor proclination and protraction, and the distance between this incisor and the mandibular plane increased. The upper molars moved forward in Group N.

In Group E, the SNA angle decreased, and point A retraction was observed. Posterior mandibular rotation caused an increase in TFH and IFH and in the MP-x angle (Table 4). The overjet became more negative due to the elimination of dental compensations: the upper incisors were retracted and retroclined, and the lower incisors were proclined and extruded. Both upper and lower molars moved forward in Group E.

An increase in TFH and IFH and the MP-x angle were observed in Group E-NO (Table 5). The overjet became more negative and the overbite decreased with lower incisors proclination and protraction, and both upper and lower molars mesialized in Group E-NO.

The comparisons between groups during the pre-surgical orthodontic treatment are presented in Table 6. There was a

**Table 2. Descriptive statistics (mean and standard deviation) and mean differences between groups in T1, for all the variables**

Variable	Mean (SD)			Mean differences at T1		
	N	E	ENO	N/E	N/ENO	E/ENO
SNA angle	80.55 (4.22)	78.95 (3.56)	79.02 (4.97)	1.60	1.53	-0.07
TFH	126.61(12.07)	115.44 (9.48)	119.64 (6.90)	11.17*	6.97	-4.20
IFH	74.49(8.76)	66.28 (6.76)	69.50 (6.04)	8.21*	4.99	-3.27
Maxillary prominence.	-2.60 (4.4)	-4.11 (3.59)	-4.15 (5.16)	1.51	1.55	0.04
Mandibular prominence.	-0.15 (8.6)	-0.60 (7.19)	-1.70 (8.82)	0.45	1.55	1.10
Chin prominence.	1.18 (8.85)	1.07 (7.64)	-0.48 (9.95)	0.10	1.66	1.55
MP-x angle	27.75 (3.44)	26.23 (6.38)	31.19 (6.94)	1.52	-3.43	-4.96
UI exposure	2.23 (2.79)	1.46 (1.53)	2.79 (2.74)	0.77	-0.55	-1.33
Overjet	-0.27 (2.88)	-0.95 (2.20)	-2.61 (3.89)	0.68	2.34	1.66
Overbite	-0.48 (2.30)	-0.62 (2.11)	1.006 (3.76)	0.15	-1.48	-1.63
UI-y (mm)	4.22 (5.10)	2.99 (5.99)	-1.260 (7.07)	1.23	5.48	4.25
LI-y (mm)	4.52 (6.94)	3.93 (5.95)	1.340 (7.17)	0.59	3.18	2.59
UI-PP (mm)	30.54 (3.40)	27.20 (2.76)	29.460 (2.94)	3.37*	1.09	-2.28
LI-MP (mm)	43.44 (5.18)	38.77 (4.69)	39.79 (2.78)	4.66*	3.64	-1.02
UI1-x angle	117.95 (3.13)	120.14 (9.72)	108.42 (7.66)	-2.19	9.53*	11.72*
LI1-x angle	67.08 (5.61)	67.70 (6.41)	70.03 (8.28)	-0.62	-2.95	-2.33
UI1-PP angle	118.38 (3.95)	120.47 (7.52)	109.72 (6.1)	-2.10	8.66*	10.75*
LI1-MP angle	85.18 (4.75)	85.96 (6.96)	78.78 (8.43)	-0.78	6.44	7.22*
Um-y (mm)	-27.95 (6.36)	-26.79 (4.21)	-26.88 (6.09)	-1.16	-1.07	.088
Lm-y (mm)	-19.40 (7.07)	-19.61 (5.53)	-20.83 (6.98)	0.21	1.43	1.22
Um-PP (mm)	26.37 (3.58)	23.40 (1.86)	24.25 (2.46)	2.98*	2.12	-0.86
Lm-MP (mm)	35.02 (5.36)	30.00 (3.83)	30.43 (3.59)	4.62*	4.59*	-0.03

\* $P<0.05$

**Table 3. Changes in Group N (no extractions) caused by the pre-surgical orthodontic treatment**

Variable	T1 Mean (SD)	T2 Mean (SD)	T2-T1 Mean (SD)	P-value
SNA angle	80.56 (4.22)	80.55(4.15)	-0.01 (0.17)	0.87
TFH	126.61 (12.07)	126.92 (11.96)	0.31 (0.56)	0.07
IFH	74.49 (8.76)	74.71 (8.79)	0.22 (0.54)	0.16
Maxillary prominence	-2.60 (4.36)	-2.58 (4.34)	0.02 (0.18)	0.66
Mandibular prominence	-0.15 (8.55)	-0.15 (8.72)	0.00 (0.43)	1.00
Chin prominence	1.18 (8.85)	1.04 (8.94)	-0.14 (0.40)	0.24
MP-x angle	27.75 (3.44)	27.81 (3.57)	0.06 (0.40)	0.59
UI exposure	2.23 (2.79)	2.71 (2.49)	0.48 (1.03)	0.11
Overjet	-0.27 (2.9)	-1.65 (2.79)	-1.38 (1.41)	0.004*
Overbite	-0.48 (2.30)	-0.55 (1.74)	-0.07 (1.39)	0.84
UI-y (mm)	4.22 (5.10)	4.05 (5.12)	-0.17 (0.49)	0.22
LI-y (mm)	4.52 (6.94)	5.68 (6.77)	1.16 (1.44)	0.01*
UI-PP (mm)	30.54 (3.40)	30.57 (3.42)	0.03 (1.18)	0.94
LI-MP (mm)	43.43 (5.18)	44.37 (5.24)	0.94 (0.90)	0.003*
UI1-x angle	117.95 (3.13)	117.98 (3.30)	0.03 (1.42)	0.92
LI1 -x angle	67.08 (5.61)	64.15 (6.04)	-2.93 (3.01)	0.004*
UI1-PP angle	118.38 (3.95)	118.19 (3.57)	-0.19 (1.57)	0.68
LI1-MP angle	85.18 (4.75)	87.96 (4.64)	2.78 (2.94)	0.005*
Um-y (mm)	-27.95 (6.36)	-27.33 (6.32)	0.62 (0.43)	0.00***
Lm-y (mm)	-19.40 (7.07)	-19.28 (7.02)	0.12 (0.27)	0.15
Um-PP (mm)	26.37 (3.59)	26.43 (3.40)	0.06 (.44)	0.62
Lm-MP (mm)	35.01 (5.36)	35.00 (5.26)	-0.01 (0.41)	0.95

\* P&lt;0.05; \*\*\* P&lt;0.001

**Table 4. Changes in Group E (extractions) caused by the pre-surgical orthodontic treatment**

Variable	T1 Mean (SD)	T2 Mean (SD)	T2-T1 Mean (SD)	P-value
SNA angle	78.95 (3.56)	78.56 (3.54)	-0.39 (0.46)	0.01*
TFH	115.44 (9.48)	116.26 (9.93)	0.82 (0.98)	0.04*
IFH	66.28 (6.76)	67.18 (7.20)	0.90 (0.96)	0.01*
Maxillary prominence	-4.11 (3.59)	-4.50 (3.58)	-0.39 (0.46)	0.01*
Mandibular prominence	-0.60 (7.19)	-0.92 (7.21)	-0.32 (0.67)	0.12
Chin prominence	1.07 (7.64)	0.78 (7.79)	-0.29 (0.92)	0.30
MP-x angle	26.23 (6.38)	26.94 (6.67)	0.71 (0.79)	0.01*
UI exposure	1.46 (1.53)	2.09 (1.49)	0.63 (1.03)	0.06
Overjet	-0.95 (2.20)	-5.20 (1.908)	-4.25 (1.18)	0.00***
Overbite	-0.62 (2.11)	-0.79 (1.94)	-0.17 (0.68)	0.41
UI-y (mm)	2.99 (5.99)	-1.27 (5.98)	-4.26 (1.19)	0.00 ***
LI-y (mm)	3.93 (5.95)	3.92 (5.90)	-0.01 (0.64)	0.96
UI-PP (mm)	27.17 (2.76)	27.24 (3.17)	0.07 (0.78)	0.77
LI-MP (mm)	38.77 (4.69)	39.60 (4.54)	0.83 (0.79)	0.004 ***
UI1-x angle	120.14 (9.72)	113.83 (8.90)	-6.31 (2.49)	0.00 ***
LI1-x angle	67.70 (6.41)	64.53 (6.03)	-3.17 (3.29)	0.007 ***
UI1-PP angle	120.48 (7.52)	114.18 (6.30)	-6.30 (3.00)	0.00 ***
LI1-MP angle	85.96 (6.96)	88.82 (5.56)	2.86 (3.05)	0.008 ***
Um-y (mm)	-26.79 (4.21)	-25.87 (4.29)	0.92 (0.55)	0.00 ***
Lm-y (mm)	-19.61 (5.53)	-19.31 (5.64)	0.30 (.34)	0.01*
Um-PP (mm)	23.39 (1.86)	23.28 (1.83)	-0.11 (0.63)	0.57
Lm-MP (mm)	30.00 (3.83)	30.62 (3.61)	0.62 (0.58)	0.22

\* P&lt;0.05; \*\*\* P&lt;0.001

larger decrease in the SNA angle and a greater retraction of point A in Group E when compared to Group N. Mandibular posterior rotation was also greater in Group E with a higher

increase in the IFH and the MP-x angle. Overjet became more negative in Group E than in Group N, due to a greater retraction and retroclination of the upper incisors.

**Table 5. Changes in Group E-NO (extractions for non-orthodontic reasons) caused by the pre-surgical orthodontic treatment**

Variable	T1 Mean (SD)	T2 Mean (SD)	T2-T1 Mean (SD)	P-value
SNA angle	79.02 (4.97)	78.95 (5.00)	-0.07 (0.31)	0.42
TFH	119.64 (6.90)	120.10 (6.75)	0.46 (0.44)	0.001*
IFH	69.50 (6.04)	69.92 (5.98)	0.42 (.38)	0.001 *
Maxillary prominence	-4.15 (5.16)	-4.21 (5.30)	-0.06 (.34)	0.56
Mandibular prominence	-1.70 (8.82)	-1.73 (8.67)	-0.03 (.28)	0.65
Chin prominence	-0.48 (9.95)	-0.44 (9.63)	0.04 (.54)	0.78
MP-x angle	31.19 (6.94)	31.57 (6.97)	0.38 (.410)	0.003 *
UI exposure	2.79 (2.74)	3.05 (2.34)	0.26 (.82)	0.23
Overjet	-2.61 (3.89)	-4.38 (3.28)	-1.77 (2.68)	0.02 *
Overbite	1.01 (3.76)	0.17 (3.36)	-0.84 (1.25)	0.02 *
UI-y (mm)	-1.26 (7.07)	-1.09 (6.77)	0.17 (1.33)	0.62
LI-y (mm)	1.34 (7.17)	3.31 (6.53)	1.97 (2.22)	0.004 *
UI-PP (mm)	29.46 (2.94)	29.73 (3.29)	0.27 (.93)	0.28
LI-MP (mm)	39.79 (2.78)	40.32 (2.26)	0.53 (1.54)	0.21
UI1-x angle	108.42 (7.66)	109.54 (6.83)	1.12 (2.91)	0.16
LI1-x angle	70.03 (8.28)	64.34 (8.87)	-5.69 (5.22)	0.001 *
UI1-PP angle	109.72 (6.10)	110.77 (5.64)	1.05 (2.72)	0.16
LI1-MP angle	78.78 (8.43)	84.13 (7.26)	5.35 (5.31)	0.001 *
Um-y (mm)	-26.88 (6.09)	-26.25 (6.03)	0.63 (0.47)	0.000 ***
Lm-y (mm)	-20.83 (6.98)	-20.53 (6.99)	0.30 (0.27)	0.001 *
Um-PP (mm)	24.25 (2.46)	24.43 (2.31)	0.17 (0.57)	0.26
Lm-MP (mm)	30.44 (3.59)	30.71 (3.50)	0.27 (0.57)	0.08

\* P&lt;0.05; \*\*\* P&lt;0.001

**Table 6. Changes produced by treatment: comparison between groups**

Variable	Group N	Group E	Group ENO	Difference between groups		
	Mean (SD)	Mean (SD)	Mean (SD)	E/N	ENO/N	E/ENO
SNA angle	-0.01 (0.17)	-0.39 (0.46)	-0.07 (0.31)	-0.38*	-0.06	-0.32*
TFH	0.31 (.56)	0.82 (0.98)	0.46 (0.44)	0.51	0.15	0.36
IFH	0.22 (.54)	0.90 (0.96)	0.42 (0.38)	0.68*	0.20	0.48
Maxillary prominence	0.02 (0.18)	-0.39 (0.46)	-0.05 (0.34)	-0.41*	-0.07	-0.34*
Mandibular prominence.	0.00 (0.43)	-0.32 (0.67)	-0.03 (0.28)	-0.32	-0.03	-0.29
Chin prominence	-0.14 (0.40)	-0.29 (0.92)	0.04 (0.54)	-0.015	0.18	-0.33
MP-x angle	0.06 (0.40)	0.71 (0.79)	0.38 (.041)	0.65*	0.32	0.33
UI exposure	0.48 (1.03)	0.63 (1.03)	0.27 (.82)	0.15	-0.22	0.37
Overjet	-1.38 (1.41)	-4.25 (1.18)	-1.77 (2.69)	-2.86*	-0.39	-2.48*
Overbite	-0.08 (1.39)	-0.17 (0.68)	-0.83 (1.25)	-0.089	-0.76	0.67
UI-y (mm)	-0.18 (.49)	-4.28 (1.19)	0.17 (1.33)	-4.09*	0.35	-4.44*
LI-y (mm)	1.16 (1.44)	-0.08 (.64)	1.98 (2.22)	-1.17	0.81	-1.98*
UI-PP (mm)	0.02 (1.18)	0.07 (0.79)	0.28 (0.93)	0.04	0.25	-0.21
LI-MP (mm)	0.93 (0.90)	0.82 (0.79)	0.53 (1.54)	-0.11	-0.40	0.30
UI1-x angle	0.04 (1.42)	-6.31 (2.49)	1.12 (2.91)	-6.31*	1.08	-7.43*
LI1-x angle	-2.92 (3.01)	-3.17 (3.29)	-5.69 (5.22)	-0.24	-2.76	2.52
UI1-PP angle	-0.18 (1.57)	-6.30 (3.00)	1.05 (2.72)	-6.11*	1.23	-7.34*
LI1-MP angle	2.78 (2.94)	2.87 (3.05)	5.40 (5.31)	0.08	2.61	-2.53
Um-y (mm)	0.62 (0.43)	0.92 (0.55)	0.62 (0.47)	0.29	0.00	0.29
Lm-y (mm)	0.12 (0.27)	0.30 (0.34)	0.31 (0.27)	0.18	0.19	-0.01
Um-PP (mm)	0.06 (.44)	-0.11 (0.63)	0.17 (0.57)	-0.17	0.11	-0.28
Lm-MP (mm)	-0.007 (0.41)	0.22 (0.58)	0.28 (0.57)	0.22	0.29	-0.06

\* P&lt;0.05; \*\*\* P&lt;0.001

When comparing Group E to Group E-NO, a significant (p<0.05) decrease in the SNA angle and a larger retraction of point A were observed in the first. Overjet also became more

negative, primarily due to a larger retraction and retroclination of the upper incisors. In Group E-NO, greater lower incisor advancement was observed in relation to the vertical plane.

There were no significant ( $p>0.05$ ) differences in the changes observed between Groups N and E-NO (Table 6).

## Discussion

Pre-surgical orthodontic treatment involves leveling and aligning of the dental arches, transverse coordination, closure of extraction spaces, and elimination of dental compensations.<sup>26</sup> Although the orthodontic treatment might involve extractions, some Class III surgical patients already have missing teeth for non-orthodontic reasons. Since this could influence the cephalometric variables measured in the present study, the patients were divided into three groups (N, E and E-NO).

Before treatment, the magnitude of the sagittal discrepancy was similar in all groups. The increased upper incisor proclination initially observed in Group E may have contributed to the decision to extract teeth in these cases. In Group E-NO, the normal upper incisor inclination could be explained by the previous absence of posterior teeth. This arch length collapse could also have been responsible for the greater retroclination observed in the lower incisors of this group. However, some degree of lower incisor retroclination was present in all groups before treatment.

During the pre-surgical orthodontic treatment, all three groups exhibited anchorage loss with mesialization of the upper first molars. In Groups E and E-NO, lower molar advancement also occurred, possibly due to closure of the extraction spaces. Although Group E initially demonstrated greater upper incisor proclination, the treatment caused significant upper incisor retraction and retroclination only in this group, resulting in an overjet more negative than in the other two groups. Alveolar bone resorption on the labial aspect of the retracted incisors caused a significant point A retraction and a reduction in the SNA angle.

According to other authors, orthodontic treatment planning without extractions in the upper arch may limit upper incisor retraction and may be responsible for the persisting post-treatment incisor proclination.<sup>15,35</sup> This situation was verified in Group N in the present study, where the upper incisors remained proclined. In Group E-NO, these teeth maintained a normal inclination even before surgery. Generally, satisfactory results depend on an adequate correction of upper incisor proclination as successful decompensation permits greater surgical movement.<sup>35,36</sup>

The lower incisors proclined in all groups and advanced in Groups N and E-NO. The success in lower incisor decompensation was verified by other authors.<sup>36</sup> However, the greater initial lower incisor retroclination in Group E-NO, caused by the absence of several posterior teeth, limited the amount of proclination achieved orthodontically and, thus these teeth were still excessively retroclined post-treatment comparing to the norm.<sup>38</sup> This association between unsuccessful lower incisor decompensation and extractions in the lower arch has been previously documented.<sup>35</sup> Persisting lower incisor retroclination can limit correction and lead to reduced ANB and excessive SNB angles even after treatment.<sup>35</sup>

Although decompensation has been described to be less successful in hyperdivergent and severe anteroposterior dis-

crepancies,<sup>37</sup> the groups were similar initially. Factors that contribute to insufficient lower incisor decompensation include lower arch extractions, severe initial lower incisor retroclination, lack of patient cooperation in the use of Class II elastics, and insufficient alveolar bone thickness to permit incisor advancement.<sup>35</sup>

One of the limitations of this investigation was the small sample size in each group since the 40 patients were subdivided into three groups. Also, Group E-NO was heterogeneous and included patients that had three or more missing teeth anterior to the upper and lower first molars.

Future studies on the long-term impact of removing dental compensations on surgical cases with and without extractions are needed. Finally, the effects of pre-surgical incisor decompensation on the soft tissues, which, although temporary, can have a strong impact on facial aesthetics, should be investigated.

## Conclusions

- 1) In Group E, there was a decrease in the SNA angle due to retraction of point A.
- 2) Mandibular clockwise rotation in Groups E and E-NO led to an increase in total and inferior facial heights.
- 3) Upper incisors were significantly retracted and retroclined only in Group E, where extractions facilitated incisor decompensation.
- 4) The lower incisor was proclined in all three groups and protracted in Groups N and E-NO. Due to the large degree of initial retroclination, the lower incisors remained retroclined in Group E-NO after treatment.
- 5) The upper first molar advanced in all the three groups.

## Ethical disclosures

**Protection of human and animal subjects.** The authors declare that no experiments were performed on humans or animals for this study.

**Confidentiality of data.** The authors declare that they have followed the protocols of their work center on access to patient data and for its publication.

**Right to privacy and informed consent.** The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

## Conflict of interest

The authors have no conflicts of interest to declare.

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