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The Long-Term Stability of the Lower Incisor Axis in Class II division 2 Malocclusions

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The purpose of this study was to evaluate the post-retention stability of the lower incisor axis in Class II division 2 malocclusions. The dental casts and lateral cephalograms from before (T1) and after (T2) orthodontic treatment and long-term post-retention (T3) in 62 Class II division 2 malocclusion cases were included in this study. After several linear and angular measurements at each time were taken, the significance in the amount of change of the lower incisor axis for each gender and extraction versus non-extraction was evaluated. The results showed that the lower incisors that inclined labially during treatment were unstable and relapsed to the original lingual position in Class II division 2 malocclusions ($p<0.001$). There was no significant difference between extraction and non-extraction groups for the amount of lingual relapse of the lower incisors ($p>0.05$). There was no significant difference between male and female groups for the axial change of the lower incisors ($p>0.05$). As a result of multiple regression analysis, the cephalometric measurement best predicting the lower incisor position to the A-Pog line post-retention was pre-treatment L1-Apog(mm) and pre-treatment SNGoMe(°).

Because of the instability of labially inclined lower incisors after orthodontic treatment, the treatment goal should be the pre-treatment incisor axial position.

Key words : Stability, Lower incisor axis, Class II division 2 malocclusion

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The anteroposterior position of the lower incisors has been regarded as one of the most important measures for orthodontic treatment planning. It has also been used to evaluate the stability of the results achieved by orthodontic treatment and the facial esthetic result.

In treating Class II division 2 malocclusions, the lower incisors are usually moved labially to correct the lingual inclination of the upper and lower incisors. Selwyn-Barnett asserted that the incisors are lingually inclined in

Class II division 2 malocclusions because the strong muscular lower lip acts as the labial curtain and it is the clinical entity which causes considerable difficulty in the provision of a stable treatment result.[1] He insisted on having the incisors in calculated proclination or designed labial inclination. Saltzmann reported that he hardly had to extract teeth when treating Class II division 2 malocclusions. Rather, he could reach a stable result by anterior movement of lower incisors.[2] According to Ricketts, labial inclination for approaching lower incisors to the A-Pog line was stable.[3] Posen preferred labial inclination of incisors over extraction to achieve a stable result, because tense perioral muscles would become normal.[4] After studying 78 cases of Ricketts, Schulhof concluded lower incisor positional change was possible and stable.[5]

On the other hand, Mills reasoned that the lower incisors have a narrow stability zone formed by the lower lip and tongue, and in spite of any directional movements lower incisors returned to the original position, therefore the treatment objective should be the original incisor axial inclination.[6,7] Hixon, Weinstein and Miller noted that in Class II division 2 malocclusions anterior movement of lower incisors was unstable and recommended extraction treatment.[8-10] Rossouw measured in 88 subjects the angle between the lower incisors and the NB line on cephalograms. He reported that because the upper incisors, orbicularis oris muscle, and other associated perioral musculature might interrupt the anterior positioning of lower incisors, lingual positioning and crowding relapse of lower incisors would surely occur after treatment.[11]

As mentioned above, there have been controversies about the ideal position of the lower incisors versus post-treatment stability. The purpose of the current study was to analyze the correlation between the amount of treatment change in lower incisor axis and the relapse tendency following the post-treatment retention period, and to evaluate the post-retention stability of the lower incisor after its labial movement in Class II division 2 subjects.

The hypotheses of this study were as follows:

Hypothesis 1 H0: Labial positioning of the lower incisor axis is unstable after orthodontic treatment in Class II division 2 malocclsions; H1: Labial positioning of lower incisor axis is stable after orthodontic treatment in Class II division 2 malocclusions.

Hypothesis 2 H0: There is no difference in stability of lower incisor axial inclination between premolar extraction and non-extraction strategies; H1: There is a difference between premolar extraction and non-extraction in the relapse tendency of the lower incisor axis.

Hypothesis 3 H0: There is no difference between males and females in the relapse tendency of the lower incisor axis; H1: There is a difference between males and females in the relapse tendency of the lower incisor axis.

The authors utilized a multiple regression equation to search for cephalometric predictors of stability. The reference line of the lower incisor used in this study was the A-Pog line, which Downs, Ricketts and Williams proposed to be the most reliable.[3,12,13]

MATERIALS AND METHODS

Materials

Orthodontic models and lateral cephalograms of 62 patients among the Class II division 2 patients under longterm follow-up in the Department of Orthodontics, University of Washington, Seattle, Washington were evaluated. They were classified into pre-treatment (T1), post-treatment (T2) and post-retention (T3) (Table 1). The mean age of the subjects were 12.7, 15.7 and 30.9 years, respectively. The mean duration from T1 to T2 was 3.0 years and the mean from T2 to T3 was 15.2 years. Minimum post-retention time was 8.6 years.

Among the subjects, 33 had been treated with consisted of the same number of males (N=31) and females (N=31).

Methods

The authors examined 34 cephalometric measure-

Table 1. The age distribution of subjects in this study (years)

	N	Minimum	Maximum	Mean	S.D.
T1	62.0	7.7	19.0	12.7	2.6
T2	62.0	11.8	21.5	15.7	2.3
T3	62.0	21.5	47.0	30.9	5.0
Tx	62.0	0.9	9.3	3.0	1.4
Tz	62.0	8.6	30.7	15.2	4.5

T1: age at pretreatment; Tx: duration from T1 to T2; T2: age at posttreatment; Tz: duration from T2 to T3; T3: age at postretention

Table 2. The twelve measurements in this study

Cephalometric measurements	Dental cast measurements
L1-APog (mm)	Curve of Spee
L1-Mn.plane (mm)	Lower irregularity index
IMPA	Upper irregularity index
FMIA	Overbite
L1-Occlusal plane	Overjet
Interincisor angle	Lower lip to E-line (mm)

ments and five dental cast measurements at pre-treatment (T1), post-treatment (T2) and post-retention (T3). Each cephalogram was traced and measured by a single examiner. The position of the lower incisor was evaluated using the A-Pog line.[11,12,16] In order to evaluate the significance of the changes of the lower incisor axis, the paired *t*-test, independent *t*-test, the Pearson Product-Moment correlation coefficient, and multiple regression analysis were used with 7 cephalometric measurements and 5 dental cast measurements. All were intimately related to the lower incisor position (Table 2).

A total of 39 cephalometric and dental cast measurements at T1, including those cited above, were tested with the Pearson correlation against L1-APog(mm) at T3. For clinical significance, only those correlations beyond r = 0.4. were used.

Cephalometric measurements (in alphabetical order)

AFH (Anterior Facial Height): the distance from Nasion to Menton; ANB: the difference between SNA and SNB; Facial depth: the distance from Nasion to Gonion; Facial length: the distance from Sella to Gnathion; FMA (Frankfort Mandibular Plane Angle): the angle between Frankfort horizontal plane and mandibular plane; FMIA (Frankfort Mandibular Incisor Angle): the angle between Frankfort horizontal plane and lower incisor axis; Gonial angle: the angle formed by Articulare, Gonion and Menton; Interincisor angle: the angle between upper incisor axis and lower incisor axis; IMPA (Incisor-Mandibular Plane Angle): the angle between lower incisor axis and mandibular plane; L1-APog (mm): the shortest distance from the lower incisor tip to A-Pog line; L1-Mandibular Plane: the shortest distance from the lower incisor axis to mandibular plane; L1-Occlusal Plane: the angle between the lower incisor axis and occlusal plane; Lower AFH: the distance from ANS to Menton; Lower Gonial Angle: the angle formed by Nasion, Gonion and Menton; Lower lip esthetics: the shortest distance from the most anterior point of lower lip to E-line; Mandibular Body Length: the distance from Gonion to Menton; ODI (Overbite Depth Indicator): A-B to mandibular plane angle ± palatal plane to FH plane angle; PFH (Posterior Facial Height): the distance from Sella to Gonion; PFH/AFH ratio: PFH to AFH ratio; PMA (Palato-Mandibular plane Angle): the angle between palatal plane and mandibular plane; Ramus Height: the distance from Articulare to Gonion; SNA: the angle between SN plane and NA line; SNB: the angle between SN plane and NB line; SN to GoMe: the angle between SN plane and mandibular plane (Go-Me); SN to Occlusal Plane: the angle between SN plane and occlusal plane; SN to Palatal Plane: the angle between SN plane and palatal plane; U1-APog (mm): the shortest distance from upper incisor tip to A-Pog line

Table 3. The results of paired t-test (total(N=62))

	T1		T2		T3
L1 to A-Pog	−2.6	***	−0.6	***	−1.9
L1 to Mn. Plane	40.1	ns	40.1	***	41.6
IMPA	90.3	***	94.8	***	91.2
FMIA	67.5	***	63.5	***	69.6
L1 to occl.plane	73.9	*	71.7	***	75.5
Interincisal angle	149.4	***	137.1	***	144.3
LL to E line	−2.5	***	−5.0	***	−7.2
Curve of Spee	2.0	***	0.3	***	0.6
L1 irregularity index	5.5	***	1.5	***	4.1
U1 irregularity index	9.6	***	1.9	***	3.1
Overbite	6.2	***	2.7	***	4.1
Overjet	3.1	***	1.7	***	2.0

***$p<0.001$; *$p<0.05$; ns: not significant

(mm); U1-FH: the angle between upper incisor axis and Frankfort horizontal plane; U1-Palatal Plane: the angle between upper incisor axis and palatal plane; Upper AFH: the distance from Nasion to ANS; Upper Gonial Angle: the angle formed by Articulare, Gonion and Nasion; Upper/Lower AFH ratio: upper AFH to lower AFH ratio; Upper lip esthetics: the shortest distance from the most anterior point of upper lip to E-line; Wits'appraisal: the linear difference between the occlusal plane intersections of A perpendicular to occlusal plane and B perpendicular to occlusal plane.

Dental cast measurements

Curve of Spee: the greatest distance from a mandibular buccal cusp to the plane connecting the mandibular incisor edges and the distal cusps of the permanent lower second molars; Lower Irregularity Index: the sum of linear displacements between the anatomic contact points of all the lower incisors; Upper Irregularity Index: the sum of linear displacements between the anatomic contact points of all the upper incisors; Overbite: the amount of the greatest vertical overlap of maxillary to mandibular central incisors in centric occlusion; Overjet: the greatest distance from the labial surface of the most labial mandibular central incisor to the labial surface of the most labial maxillary central incisor.

RESULTS

Labial positioning of the lower incisors (Table3)

Regarding hypothesis 1, a total of 12 measurements were tested with paired t-tests. There was a statistically significant difference in the amount of relapse of the lower incisors in the lingual direction from T2 to T3 for all measurements ($p<0.001$). Therefore the research hypothesis that labial incisor proclination is stable in Class II division 2 cases proved not to be true.

Extraction (N=33) versus non-extraction (N=29) (Table 4) and male (N=31) versus female (N=31)

Regarding hypothesis 2, independent t-tests of cephalometric values for extraction versus non-extraction cases showed no significant difference.

For model variables, lower arch Irregularity Index was significantly higher for the extraction group at T1, but there was no significant difference at T2 or T3. Overbite was significantly deeper for the non-extraction group at both T2 and at T3. Overjet was significantly greater for the non-extraction group, only at the end of active treatment, T2.

Relative to hypothesis 3, independent t-test evaluation of male versus female response of lower incisor axial inclination relapse, showed no significant difference.

Table 4. The result of independent *t*-test (extraction vs non-extraction)

	T1			T2			T3			Tx			Tz		
	non-ext N=29	ext N=33		non-ext N=29	ext N=33		non-ext N=29	ext N=33		non-ext N=29	ext N=33		non-ext N=29	ext N=33	
L1 to A-Pog	−3.2	−2.0	ns	−1.1	−0.1	ns	−2.2	−1.7	ns	2.1	2.0	ns	−1.1	−1.6	ns
L1 to Mn. Plane	39.5	40.7	ns	39.8	40.3	ns	41.4	41.7	ns	0.3	0.0	ns	1.6	1.4	ns
IMPA	90.2	90.5	ns	93.8	95.6	ns	91.4	91.1	ns	3.6	5.0	ns	−2.4	−4.5	ns
FMIA	69.2	66.1	ns	65.9	61.4	*	71.2	68.1	ns	−3.3	−5.0	ns	5.3	6.6	ns
L1 to occl.plane	75.6	72.5	ns	73.1	70.4	ns	76.2	74.9	ns	−2.5	−2.0	ns	3.1	4.4	ns
IIA	151.3	147.7	ns	139.1	135.3	ns	145.1	143.6	ns	−12.1	−12.0	ns	5.9	8.3	ns
LL to E line	−3.0	−2.0	ns	−5.4	−4.5	ns	−7.8	−6.7	ns	−2.4	−3.0	ns	−2.4	−2.2	ns
Curve of Spee	2.1	1.8	ns	0.4	0.1	ns	0.7	0.5	ns	−1.7	−1.7	ns	0.3	0.4	ns
L1 irregularity Index	3.8	7.1	***	1.6	1.4	ns	3.6	4.4	ns	−2.1	−5.7	***	2.0	3.0	ns
U1 irregularity Index	7.8	11.1	ns	1.8	1.9	ns	2.9	3.2	ns	−6.0	−9.3	**	1.1	1.3	ns
Overbite	6.6	5.9	ns	3.3	2.2	***	4.6	3.8	*	−3.3	−3.7	ns	1.3	1.6	ns
Overjet	3.0	3.3	ns	1.9	1.5	*	2.0	2	ns	−1.1	−1.8	ns	0.1	0.5	ns

***p<0.001; **p<0.01; *p<0.05; ns: not significant

Table 5. The correlation between the relapse tendency in L1-APog (mm) Postretention (T3) and other cephalometric measurements pretreatment (T1)

Cephalometric measurements	Correlation coefficient		Cephalometric measurements	Correlation coefficient	
AFH	0.06	ns	OB	−0.52	***
ANB	0.14	ns	OJ	0.32	*
Curve of Spee	−0.38	**	PFH	−0.25	*
Facial depth	−0.19	ns	PFH/AFH	−0.45	***
Facial length	−0.11	ns	PMA	0.46	***
FMA	0.34	**	Ramus height	−0.23	ns
FMIA	−0.47	***	SNA	0.01	ns
Gonial angle	0.30	*	SNB	−0.1	ns
IIA	−0.62	***	SNGoMe	0.49	***
IMPA	0.25	*	SN-Occl.plane	0.24	ns
L1-APog(mm)	0.74	***	SN-Palatal plane	0.08	ns
L1-Mn.Plane	0.09	ns	U1-APog(mm)	0.71	***
L1-Occl.Plane	−0.44	***	U1-FH	0.52	***
Lower AFH	0.11	ns	U1-Pal.plane(mm)	0.1	ns
Lower Gonial angle	0.45	***	Upper AFH	−0.02	ns
Lower lip esth.	0.53	***	Upper Gonial angle	0.07	ns
Mn. Body	−0.24	ns	Upper/LowerAFH	0.16	ns
ODI	−0.45	***	Upper lip esth.	0.27	ns
			Wits' applaisal	−0.16	ns

***p<0.001; **p<0.01; *p<0.05; ns: not significant

Correlation and regression analysis (Table 5 and Table 6)

To study pre-treatment predictors of post-retentionrelapse, 37 cephalometric and dental cast measurements including 12 measurements at T1 were correlated with L1-APog (mm) at T3 by Pearson's correlation with r = 0.4 the level of clinical significance.

Table 6. The value coefficients obtained for multiple regression equation

	Standardized coeff	Constant	t	sig.
L1Apog (mm)	0.74	−3.4E−02	8.46	***
L1Apog (mm)	0.65	−3.387	6.91	***
SNGoMe	0.21		2.24	*

***p<0.001; *p<0.05; ns: not significant

Those that showed clinical significance were studied further with multiple regression analysis. The most significant variable was L1−APog(mm) and secondly, L1−APog(mm) plus SN−GoMe(°).

The following multiple regression equation was developed:

(1) L1−APog(mm)3=0.74 * L1−APog(mm)1−3.4 * 10^{-2} (R^2=0.54)

(2) L1−APog(mm)3=0.65 * L1−APog(mm)1 + 0.21 * SN GoMe1−3.387 (R^2=0.58)

L1−APog(mm)1: the shortest length from the lower incisor edge to APog line at T1

L1−APog(mm)3: the shortest length from the lower incisor edge to APog line at T3

SN−GoMe1: the angular measurement between SN plane and GoMe (mandibular plane) at T1

DISCUSSION

Many years after removal of lower arch retention, the lower incisor axes of Class II division 2 patients who underwent orthodontic proclination of lower incisors, showed significant lingual axial relapse. This finding seems unrelated to extraction versus non−extraction or to gender.

The significant lingual axial relapse of lower incisors which were labially inclined during treatment was in agreement with past studies.[6−11] Shields and Little studied 54 cases treated with first premolar extraction during adolescence. They reported that it was impossible to predict the long−term axial change of the lower incisors but the labially flared lower incisor was sure to show a stong relapse tendency post−retention.[14] They postulated two causes of relapse: First, it is the trend for the teeth to take the most natural position. Brodie, et al., asserted that the tooth axis would change post−treatment. Having studied 21 premolar extraction cases for at least a year post−retention, Cole reported that the lower incisors would return to their original axes relative to the mandibular plane and this trend toward the upright position could cause crowding.[15] According to Margolis, lower incisors tend to upright into a more stable position.[16] Tweed asserted that the lower incisors would be stable and natural when upright to the madibular plane.[17] Second, uprighting may be due to facial growth. Bjrk and Skieller pointed out that the crowding of lower incisors could occur secondarily to the complex facial development.[18] Nanda and Zernik asserted that the crowding of the lower incisors could worsen due to growth and maturation.[19]

Extraction and non−extraction cases showed a few differences in relapse response. This finding was in agreement with what Rossouw in 1993 had observed in 88 cases for 7 years posttreatment[11]. Rossouw measured the lower incisor axis relative to the NB line. He reported that extraction and non−extraction groups had a similar trend toward relapse (p>0.05). In Table 4, it is shown that two dental cast measurements, namely the Irregularity Index of the lower incisors at T1 and the posttreatment T2 overbite, are significantly different between the extraction and non−extraction groups. The Irregularity Index of the lower incisors in the extraction group at T1 was significantly greater (p<0.001). But the Index became similar with that of the non−extraction group at T2 and T3, which suggested that neither extraction nor non−extraction resulted in greater stability. This is in agreement with Little's view when looking very long term, at least 20 years post−retention[20]. The overbite in the non−extraction group at T2 and T3 was significantly greater than the extraction group. The amount of overbite change during and after treatment however, was not different between extraction and non−extraction groups.

The change of the lower incisor axis showed no sig−

nificant difference between males and females. Although there were many studies on the lower incisor position in normal occlusions or treated malocclusions, there was no study on post-treatment cephalometric changes in only Class II division 2 cases. In normal occlusions, no gender difference was found in cephalometric positional change of the lower incisors.[21,22]

Finally, the authors examined a total of 37 pre-treatment cephalometric measurements to find the predictor of lower incisor axis at T3. The measurements with the largest correlation coefficients ($p<0.001$), were used in a multiple regression analysis with L1-APog (mm) at T3 as the dependent variable. The most significant measurements were L1-APog (mm) and SN-GoMe (°) at T1. This suggested that the lower incisors would return to the pre-treatment position after orthodontic treatment, and that the pre-treatment L1-APog (mm) should be the reference of lower incisor movement. This agreed with the opinion of Mills and Rossouw that the treatment objective should be the pre-treatment original position[6,7,11,23]. The skeletal measurement SN-GoMe (°) showed that each patient's vertical factors may be related to the lower incisor axis. In other words, if one has a steep mandibular plane angle before treatment, the patient's increased lower incisor position at post-retention can be better maintained.

In Table 6, each of the models 1 and 2 could predict 54% and 58% of all cases. Therefore, labial tipping or bodily movement of the lower incisor is limited in Class II division 2 malocclusions. The final position of the lower incisors should be where the lower incisor was located relative to A-Pog line before treatment. The amount of lower incisor movement, however, can be altered according to skeletal vertical factors such as the mandibular plane angle. Its limits may be judged by the multiple regression equation yielded in this study. As to the relationship between the cephalometric measurements and dentitional relapse tendency like crowding, in 1985 Shields, Little and Chapko reported that there is a scarce correlation between the cephalometric and the dentitional measurements and it would be impossible to predict the long-term changes of the lower incisor position such as crowding relapse[14]. Little, Riedel and Artun asserted that it would be hard to predict the changes after 10-20 years from the pre-treatment record or treatment results in terms of the long-term stability of the lower incisors[20]. As the current study showed, the sample was confined to Class II division 2 and it was possible to obtain a prediction formula with higher utility than those of other studies.

CONCLUSION

1. The position of lower incisors that inclined labially during treatment was unstable and relapsed lingually in Class II division 2 malocclusions.
2. There was no significant difference between extraction and non-extraction groups for the amount of lingual relapse of lower incisors.
3. There was no significant difference between males and females for the axial relapse change of the lower incisors.
4. As a result of multiple regression analysis, the cephalometric measurement determining the lower incisor position to A-Pog line post-retention was L1-APog(mm) and SN-GoMe (°). The calculated multiple regression equation was as follows:

(1) $L1\text{-}APog(mm)3 = 0.74 * L1\text{-}APog(mm)1 - 3.4 * 10^{-2}$ ($R^2=0.54$)

(2) $L1\text{-}APog(mm)3 = 0.65 * L1\text{-}APog(mm)1 + 0.21 * SNGoMe1 - 3.387$ ($R^2=0.58$)

L1-APog(mm)1: the shortest length from the lower incisor edge to APog line at T1;
L1-APog(mm)3: the shortest length from the lower incisor edge to APog line at T3;
SN-GoMe1: the angular measurement between SN plane and GoMe(mandubular plane) at T1.

Because of instability of labially inclined lower incisors after orthodontic treatment, it is recommended to maintain the original upright position. With a larger vertical skeletal component, the amount of lingual axial relapse may be less.

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국문초록

제II급 2류 부정교합에서 하악 절치 치축의 장기적인 안정성에 관한 연구

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이 연구의 목적은 제II급 2류 부정교합에서 하악 절치 치축의 보정 이후 안정성을 평가하는 것이다. 62명의 제II급 2류 부정교합 증례들에서 교정 치료전(T1)과 치료후(T2) 그리고 장기간의 보정 이후(T3)의 치아 모형과 측모 두부 방사선 사진들을 이 연구에 사용하였다. 각 시기별로 여러 개의 선 및 각도 계측을 시행하고 각 성별과 발치-비발치에 대한 하악 절치 치축 변화량의 유의성을 평가하였다. 그 결과, 제II급 2류 부정교합 치료 동안 순측으로 경사된 하악 절치들은 불안정하였고 원래의 설측 위치로 되돌아 갔다($p<0.001$). 하악 절치들의 설측 재발량에 대하여는 발치와 비발치 군 사이에 유의한 차이는 없었다($p>0.05$). 하악 절치들의 축변화에 대하여는 남녀군 사이에 유의한 차이가 없었다($p>0.05$). 다중 회귀 분석의 결과, 보정 이후 A-Pog선에 대한 하악 절치의 위치를 가장 잘 예측하는 두부계측 방사선 계측 항목은 치료전 L1-Apog(mm)과 치료전 SNGoMe(°)였다.

교정치료 이후 순측으로 경사된 하악 절치들의 불안정성 때문에 치료 목표는 치료전 절치 치축의 위치가 되어야 한다.

주요 단어 : 안정성, 하악절치치축, 제 II 급 2류 부정교합

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