Original Article

Long-term evaluation of Class II subdivision treatment with unilateral maxillary first molar extraction

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ABSTRACT

Objective: To evaluate the long-term effects of asymmetrical maxillary first molar (M1) extraction in Class II subdivision treatment.

Materials and Methods: Records of 20 Class II subdivision whites (7 boys, 13 girls; mean age, 13.0 years; SD, 1.7 years) consecutively treated with the Begg technique and M1 extraction, and 15 untreated asymmetrical Class II adolescents (4 boys, 11 girls; mean age, 12.2 years; SD, 1.3 years) were examined in this study. Cephalometric analysis and PAR assessment were carried out before treatment (T1), after treatment (T2), and on average 2.5 years posttreatment (T3) for the treatment group, and at similar time points and average follow-up of 1.8 years for the controls.

Results: The adjusted analysis indicated that the maxillary incisors were 2.3 mm more retracted in relation to A-Pog between T1 and T3 ($\beta = 2.31$; 95% CI; 0.76, 3.87), whereas the mandibular incisors were 1.3 mm more protracted ($\beta = 1.34$; 95% CI; 0.09, 2.59), and 5.9° more proclined to the mandibular plane ($\beta = 5.92$; 95% CI; 1.43, 10.41) compared with controls. The lower lip appeared 1.4 mm more protrusive relative to the subnasale-soft tissue-Pog line throughout the observation period in the treated adolescents ($\beta = 1.43$; 95% CI; 0.18, 2.67). There was a significant PAR score reduction over the entire follow-up period in the molar extraction group ($\beta = -6.73$; 95% CI; -10.7, -2.7). At T2, 65% of the subjects had maxillary midlines perfectly aligned with the face.

Conclusions: Unilateral M1 extraction in asymmetrical Class II cases may lead to favorable occlusal outcomes in the long term without harming the midline esthetics and soft tissue profile. (*Angle Orthod.* 2015;85:757–763.)

KEY WORDS: Class II subdivision; Maxillary first molar extraction; Cephalometrics; PAR

INTRODUCTION

Correction of Class II subdivision malocclusion has long been a challenge for clinicians. Through the years, a wide variety of treatment modalities have been implemented, such as use of asymmetrical headgear[1]; unilateral Class II elastics coupled with a coil spring, sliding jigs, or tip-back mechanics on the affected side[2]; one, three, or four premolar extractions[3,4]; bimaxillary surgical procedures[5]; TADs-supported unilateral molar distalization[6]; and a fixed functional appliance.[7]

Despite strong clinical interest, few studies on Class II subdivision treatment have been published. Janson and colleagues observed slightly better treatment success rates in asymmetric extraction of three premolars compared with extraction of four.[3] Smile attractiveness and buccal corridors did not differ in Class II subdivision subjects treated with one, three, or four premolar extractions.[4]

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Table 1. Summary Statistics (Means, SD in Parentheses) of the Treatment and Control Groups

	Treatment (n = 20)	Control (n = 15)
Gender		
Male	7	4
Female	13	11
Age (y)		
T1	13.0 (1.7)	12.2 (1.3)
T2	15.3 (1.9)	14.0 (1.6)
T3	17.7 (1.9)	15 (1.8)

A retrospective study of varying treatment strategies, ie, intermaxillary elastics, extractions, asymmetrical headgear, fixed functional appliance, and orthognathic surgery, demonstrated comparable occlusal outcomes.[8] Finally, whereas Herbst treatment was similarly successful in various Class II malocclusions, a Class III tendency was more frequently evident in the subdivision group.[7]

Recently, unilateral extraction of a maxillary first molar (M1) followed by fixed appliance treatment has also been advocated in a case report with a favorable result.[9] However, no case series or long-term follow-up studies have yet been published on the treatment of unilateral M1 extraction in Class II subdivision malocclusion.

Therefore, the objective of this study was to assess long-term treatment changes in a sample of Class II subdivision patients treated with one M1 extraction and fixed appliances.

MATERIALS AND METHODS

This retrospective study included 20 Class II subdivision subjects (7 males, 13 females; mean age, 13.0 years; SD, 1.7 years) all consecutively treated by one orthodontist with the Begg light-wire appliance in his private practice (Table 1). The inclusion criteria were white race, Class II subdivision (defined as a unilateral Class II ≥ 1/2 premolar width and Class I on the other side), no missing teeth or tooth agenesis including third molars, permanent dentition, no or mild crowding in the mandibular arch, and unilateral M1 extraction on the Class II side. Clinical records were obtained before treatment (T1), after treatment (T2), and 2.5 years posttreatment on average (T3; range, 1.8 years–4.3 years).

The control subjects were untreated Class II subdivision adolescents (4 males, 11 females; mean age, 12.2 years; SD, 1.3 years at the start of the observation period) selected and matched by age from the archives of the Groningen Longitudinal Growth Study (Table 1).[10–12]

All lateral head films were scanned (Epson Expression 1680 Pro, Suwa, Nagano, Japan) and subsequently digitized by the first author using cephalometric software (Viewbox 3.0; dHAL Software, Kifissia, Greece). The landmarks and reference lines used for the analysis are displayed in Figure 1. The same calibrated examiner scored all study casts using the peer assessment rating (PAR) twice, with a 1-week interval between observations. Twelve tracings and PAR scores were randomly selected and repeated at least 2 weeks after the initial series of measurements to evaluate intraobserver reliability. Joint Photographic Experts Group images of patient smiles were imported into image processing software (Image J version 1.48v, US National Institutes of Health, Bethesda, Md) to assess midline asymmetry. Image J was set to define facial and dental midlines and calculate the linear distance between the midlines.

Statistical Analysis

Descriptive statistics (means, standard deviations) were calculated for all cephalometric and PAR

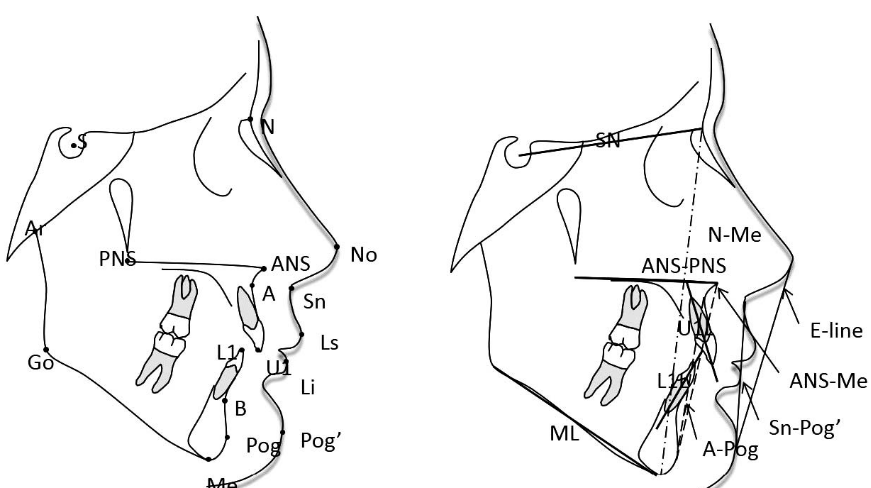

Figure 1. Landmarks (left) and reference lines (right) included in the cephalometric analysis of the study.

Table 2. Means and SDs of PAR Scores and Cephalometric Measurements

	T1		T2		T3	
	Control	Treatment	Control	Treatment	Control	Treatment
Dental cast analysis						
PAR	15.6 (7.1)	22.1 (7.2)	16.3 (7.3)	2.0 (2.5)	16.9 (9.1)	2.3 (2.5)
Cephalometric analysis						
SNA (°)	81.9 (4.0)	84.8 (4.1)	81.7 (3.3)	83.1 (4.8)	81.5 (3.8)	83.2 (5.4)
SNB (°)	77.8 (3.3)	79.7 (3.8)	77.8 (3.1)	79.2 (3.9)	77.8 (3.7)	79.5 (4.6)
ANB (°)	4.0 (1.9)	5.1 (1.7)	4.0 (1.9)	3.9 (2.5)	3.7 (2.1)	3.6 (2.5)
SN/ANS-PNS(°)	7.7 (2.9)	4.8 (4.2)	8.2 (3.4)	5.1 (4.3)	7.6 (2.3)	5.2 (4.8)
SN/ML (°)	32.2 (5.8)	29.1 (6.2)	32.0 (5.4)	29.5 (6.4)	31.8 (5.7)	28.7 (7.0)
ANS-PNS/ML (°)	24.5 (5.1)	24.4 (5.0)	23.7 (5.2)	24.4 (5.0)	24.2 (5.5)	23.6 (5.4)
ANS-Me/N-Me (ratio)	55.7 (2.0)	57.0 (2.6)	55.6 (1.7)	57.5 (2.4)	56.0 (1.8)	57.6 (2.2)
U1L/ANS-PNS (°)	108.1 (8.0)	112.1 (6.7)	108.7 (8.4)	110.2 (5.5)	109.6 (6.5)	109.8 (6.3)
U1 to A-Pog (mm)	4.4 (2.2)	7.7 (3.1)	4.1 (2.1)	5.7 (2.4)	4.6 (1.7)	6.0 (2.5)
L1L/ML (°)	94.2 (6.7)	98.5 (8.2)	94.9 (7.2)	100.5 (7.4)	94.9 (6.5)	102.1 (6.4)
L1 to A-Pog (mm)	0.5 (1.8)	1.5 (2.4)	0.4 (1.7)	2.4 (2.1)	0.8 (1.7)	2.8 (2.1)
Overbite (mm)	2.9 (1.3)	2.3 (2.4)	2.7 (1.3)	1.3 (1.5)	2.6 (1.8)	1.3 (1.2)
Overjet (mm)	4.0 (1.3)	6.4 (2.0)	3.9 (1.5)	3.4 (1.5)	3.9 (1.6)	3.4 (1.1)
Nasolabial angle (°)	124.8 (5.9)	126.9 (9.4)	124.5 (7.2)	129.8 (7.5)	125.5 (6.4)	128.9 (7.9)
Ls to Sn-Pog (mm)	3.4 (1.7)	4.4 (1.9)	3.3 (1.8)	3.0 (2.1)	3.3 (1.5)	3.1 (1.7)
Li to Sn-Pog (mm)	1.5 (2.1)	3.3 (2.1)	1.7 (2.4)	2.8 (2.2)	1.9 (2.0)	2.6 (1.9)
Ls to E-line (mm)	−2.6 (2.2)	−1.8 (2.1)	−2.8 (2.4)	−4.2 (3.0)	−2.8 (1.8)	−4.3 (2.5)
Li to E-line (mm)	−2.2 (2.3)	−0.4 (2.3)	−2.0 (2.8)	−1.7 (2.5)	−2.0 (2.0)	−1.9 (2.6)
N-No (mm)	46.7 (6.0)	49.3 (7.4)	46.4 (2.9)	51.9 (7.3)	47.0 (2.0)	52.5 (9.9)
Ls-U1 (mm)	15.0 (2.6)	14.9 (2.7)	15.0 (2.3)	16.0 (3.1)	14.2 (2.6)	16.2 (3.4)
Li-L1 (mm)	14.5 (2.6)	16.5 (3.3)	14.5 (1.9)	15.2 (3.0)	14.6 (1.4)	15.3 (2.5)

measurements. Intraobserver reliability was assessed using the intracluster correlation coefficient (ICC). The effect of the intervention on the parameters of interest was assessed by fitting a mixed linear model in which each outcome of interest was regressed on treatment, time point, patient age, and outcome baseline value. The mixed model accounts for the correlated nature of data arising from the fact that there are multiple observations within patients; the patient was used as the random effect. The level of statistical significance was set at 5%. Statistical analysis was performed with Stata version 13 software (Stata Corporation, College Station, Texas).

RESULTS

The ICC ranged from 0.75 to 0.99, indicating excellent intraobserver reliability. Demographics and summary values (mean, SD) for the study and control groups are presented in Tables 1 and 2. The results from the adjusted analyses for the effects of therapy on the parameters of interest are shown in Table 3.

Cephalometric Analysis

Superimposition of the mean tracings at all three time points illustrates the overall treatment and growth effects (Figure 2). Six cephalometric variables (U1 to A-Pog, L1/ML, L1 to A-Pog, Li to Sn-Pog′, N-No, ANS-Me/N-Me) showed a statistical significant association with treatment (Table 3).

The adjusted analysis indicated that during therapy, the maxillary incisors were retracted 2.3 mm more than were the control teeth in relation to A-Pog ($\beta = 2.31$; 95% CI: 0.76, 3.87). At T3, the maxillary incisors

Table 3. Results of Mixed Model Analysis

Variable	β-coefficient	95% CI	*P* Value
Dental cast analysis			
PAR	−6.73	−10.73, −2.73	.001*
Cephalometric analysis			
SNA (°)	1.68	−1.05, 4.40	.29
SNB (°)	1.10	−1.31, 3.52	.37
ANB (°)	0.52	−0.77, 1.82	.43
SN/ANS-PNS (ratio)	−2.78	−5.18, 0.38	.02
SN/ML (°)	−2.61	−6.60, 1.39	.20
ANS-PNS/ML (°)	−0.03	−3.32, 3.26	.99
ANS-Me/N-Me (ratio)	1.63	0.26, 3.01	.02*
U1L/ANS-PNS (°)	2.32	−1.87, 6.52	.28
U1 to A-Pog (mm)	2.31	0.76, 3.87	.004*
L1L/ML (°)	5.92	1.43, 10.41	.01*
L1 to A-Pog (mm)	1.34	0.09, 2.59	.04*
Overbite (mm)	−0.85	−1.76, 0.05	.06
Overjet (mm)	0.68	−0.21, 1.57	.14
Nasolabial angle (°)	3.87	−0.42, 8.16	.08
Ls to Sn-Pog (mm)	0.23	−0.80, 1.25	.66
Li to Sn-Pog (mm)	1.43	0.18, 2.67	.02*
Ls to E-line (mm)	−0.45	−1.81, 0.91	.52
Li to E-line (mm)	1.01	−0.41, 2.43	.16
N-No (mm)	3.97	0.62, 7.33	.02*
Ls-U1 (mm)	1.12	−0.41, 2.65	.15
Li-L1 (mm)	1.28	−0.08, 2.64	.06

* *P* values $<$ .05.

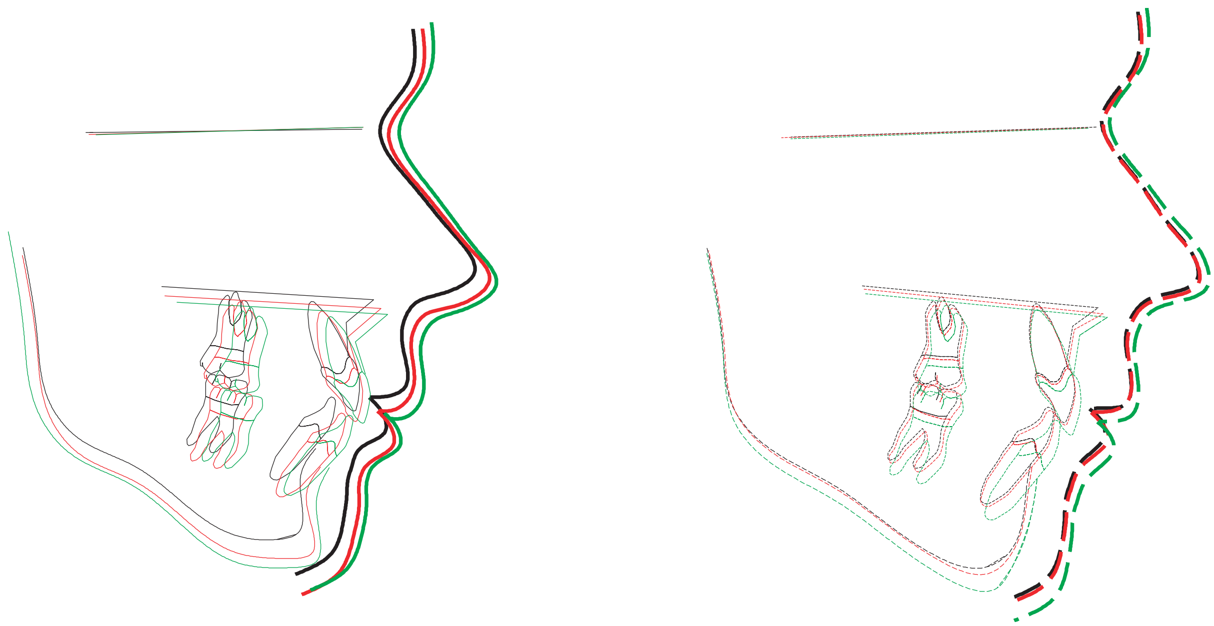

Figure 2. Mean tracings of the treatment (left) and control group (right): black, T1; red, T2; green, T3.

relapsed in both groups but remained retracted compared with pretreatment standards in the treated adolescents (mean = 6.0; SD = 2.5). Treatment also had a significant effect on the mandibular incisor position relative to A-Pog (β = 1.34; 95% CI: 0.09, 2.59). In the treatment group, the mandibular incisors were protracted 0.9 mm between T1 and T2 (at T2; mean = 2.4; SD = 2.1) and 0.4 mm at T3 (mean = 2.8; SD = 2.1). In the growth study sample, the mandibular incisors were slightly retracted at T2 (mean = 0.4; SD = 1.7 mm) and moved in the opposite direction at follow-up (mean = 0.8; SD = 1.7).

In the extraction group, the mandibular incisor to mandibular plane angle increased significantly from T1 to T3 (β = 5.92; 95% CI: 1.43, 10.41) compared with control, namely, from 98.5° (SD = 8.2) to 102.1° (SD = 6.4). The mandibular incisors in the untreated controls proclined after treatment (mean = 94.9; SD = 7.2) and remained stable during the posttreatment period (mean = 94.9; SD = 7.2).

Regarding soft tissue measurements, the significant maxillary incisor retraction was not accompanied by equivalent changes either in the upper lip position or the nasolabial angle (Table 3). Following the significant treatment effects on L1/ML and L1 to A-Pog, the lower lip appeared significantly more protrusive relative to Sn-Pog′ throughout the observation period in the treatment group (β = 1.43; 95% CI: 0.18, 2.67). On the contrary, projection of the labrale inferius was decreased in the matched controls by 0.2 mm from T1 to T2 (at T2; mean = 1.7, SD = 2.4) and from T2 to T3 (at T3; mean = 1.9, SD = 2.0).

The ratio ANS-Me/N-Me was significantly increased from T1 to T3 in the treatment group (β = 1.63; 95% CI: 0.26, 3.01) indicating an increase in lower face height that we did not consider clinically significant.

Not related to treatment, the nose became significantly more prominent in the treated subjects (β = 3.97: 95% CI: 0.62, 7.33).

Dental Cast Analysis

According to the adjusted model, PAR exhibited a significant decrease with treatment compared with the control group (β = −6.73; 95% CI: −10.73, −2.73, Figure 3). The average PAR score in the treatment group at T1 was 22.05 (SD = 7.2), which was reduced to 2.00 (SD = 2.5) at the end of treatment. PAR reduction for the unilateral molar extraction group exceeded 90%. All but three cases exhibited PAR scores lower than 6 at the follow-up examination. In contrast, there was a mean absolute increase of 1.3 points in the PAR score of the untreated subjects from T1 to T3 (Figure 2).

Midline Asymmetry

Initially, in 13 out of 20 adolescents (65%) from the treatment group, the mandibular midline did not correspond with the facial midline. Both dental midlines deviated in five cases (25%), while the remaining subjects (10%) had a shift of the maxillary midline in relation to the facial midline. After removal of appliances, facial and dental midlines were coincident in nine patients (45%). The maxillary-to-facial midline

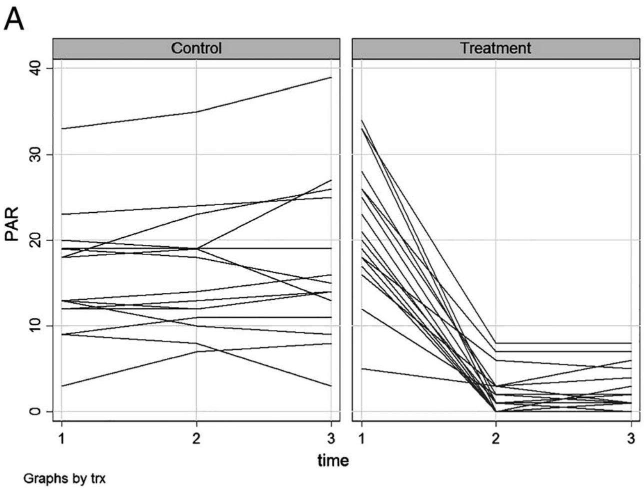

Figure 3. (A) PAR changes for the treatment and control groups by time point and per individual.

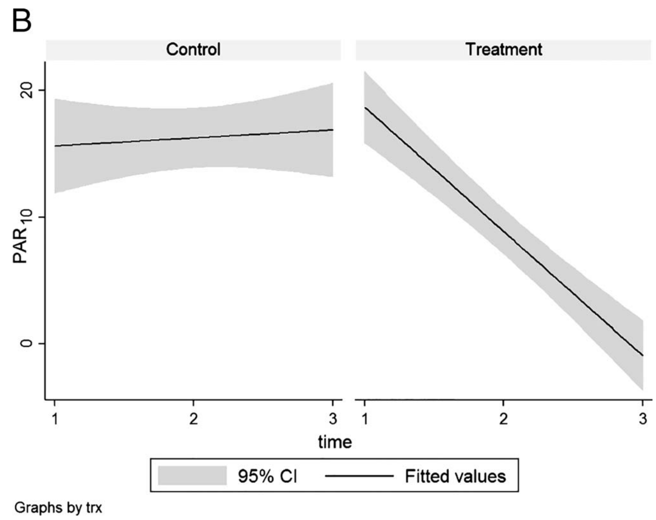

Figure 3. (B) Fitted PAR changes and associated 95% confidence intervals calculated from the linear mixed model per treatment and control groups.

discrepancy was fully addressed by the therapy in thirteen subjects (65%).

Deviation between maxillary midline to face and between dental midlines ranged between 0.3–2.1 mm and 0.5–1.2 mm, respectively, after treatment. At T2, nine individuals appeared to have midlines perfectly aligned with the face. Midline characteristics of the study group are summarized in Table 4.

DISCUSSION

This is the first clinical study to evaluate long-term changes in Class II subdivision orthodontic patients undergoing unilateral M1 extraction. During the observation period, the maxillary incisors were significantly retracted in the treatment group, whereas comparable changes in lip projection and nasolabial angle did not take place. In contrast, the only previous study on extraction treatment of asymmetrical Class II malocclusion[13] that cephalometrically compared three-premolar with four-premolar extraction protocols showed no significant changes in maxillary incisor displacement between groups immediately after treatment. The great variability in the amount of retraction in the abovementioned study, probably resulting from varying premolar extraction patterns within the groups, might have contributed to the lack of significant differences. Nevertheless, retraction of the upper lip was significantly greater in cases wherein four premolars had been extracted. As pointed out in our results, proper axial inclination of maxillary incisors was maintained during an average retraction of 2.1 mm relative to the A-Pog line, while the upper lip followed on average 66% of the maxillary incisor movement. In contrast, Stalpers and colleagues[14] found that the upper lip moved half the distance in the same direction as the maxillary incisors in cases of bilateral M1 extractions.

In Class II therapy with extraction of two maxillary first premolars, patients exhibited significantly more retruded maxillary central incisors after treatment than those with premolar extractions in both jaws or nonextraction therapy.[15] Yet, the distance between upper and lower lips to the esthetic line increased highly significantly in all groups regardless of extraction patterns. These investigators noted slight but insignificant increase in the nasolabial angle between the start and end of treatment in all groups. In another two-maxillary-premolar-extraction study, correction of a mean overjet of 8.6 mm was accompanied by significant retraction of the maxillary incisors and labrale superius and an increase in the nasolabial angle.[16] Nonetheless, these authors concluded that the upper lip did not respond uniformly to the distal movement of the maxillary incisors, and therefore potential decrease of lip projection should not be a matter of concern in less severe Class II division 1 malocclusions. In this context, Katsaros,[17,18] based on relatively small changes in the sagittal position of the lips in both extraction and nonextraction patients,

Table 4. Summary Values (Means, SD) of Maxillary Midline-face and Maxillary-mandibular Midline Discrepancies

	T1		T2		T3	
Variables	Mean	SD	Mean	SD	Mean	SD
Maxillary midline to face (mm)	0.4	0.7	0.4	0.7	0.4	0.7
Maxillary to mandibular midline (mm)	1.7	0.9	0.3	0.4	0.4	0.5

claimed that the influence of growth of the chin and nose on the facial profile might be more important than the extractions themselves.

Leveling of the curve of Spee and tooth alignment in treated subjects were accompanied by a significant proclination and protrusion of the mandibular incisors relative to A-Pog and a similar forward movement of the lower lip as measured by the vertical distance from the subnasale-soft-tissue-Pog line. These findings are consistent with the changes observed in dental and soft tissue parameters after the extraction of two M1s.[14] Moreover, the resulting forward movement of the mandibular incisors reduced the required amount of maxillary incisor retraction and apparently enhanced esthetics. Previous analysis of overjet correction with the same low-friction appliances in bilateral M1 extraction cases showed that approximately one-third of the anteroposterior correction was achieved by protrusion of the mandibular incisors.[19]

With reference to the skeletal measurements, we found a statistically significant increase in lower-face vertical dimension in the treated subjects. However, the 0.1%–0.5% increase in the ratio of lower anterior facial height to total anterior facial height between time points can be considered clinically irrelevant. Given that such vertical skeletal increase was not apparent in the controls, it can be assumed that it most likely resulted from orthodontic extrusive mechanics during incisor retraction and use of Class II elastics rather than normal craniofacial growth and development. In line with our results, lower face height increased in camouflage therapy of Class II division 1 whites having two maxillary first premolars extracted[16,20] and two M1s extracted in the horizontal- and normal-vertical-face-height patients.[14]

The statistically significant increase in nose length in the treated subjects may be due to the inclusion of older patients and more males than in the control group. It has been previously demonstrated that essential changes in facial convexity, primarily resulting from an increase in nasal prominence relative to the rest of the soft tissue profile, occur earlier in females (at 10–15 years) than in males (15–25 years).[21]

The M1 extraction cases underwent an average reduction of more than 20 PAR points, whereas the malocclusion was slightly increased in untreated controls. According to PAR conventions, a minimum change in the weighted PAR score of 22 points is required for a case to be classified as "greatly improved."[22] Owing to the asymmetrical Class II malocclusion, our study group initially presented only moderate overjet, which diminished the severity of the malocclusion, and did not a potentially greater PAR reduction after treatment. Nevertheless, as indicated by the improved occlusal outcomes after treatment, the patients benefited substantially from treatment with an M1 extraction.

Similar to past studies on classification of Class II subdivision malocclusion,[13,23] midline asymmetry was most commonly located in the mandibular arch. At T2, maxillary and mandibular midlines were harmonized with the midline of the face in approximately half the subjects. Recent research on smile esthetics has demonstrated maximum acceptable maxillary midline-to-face discrepancies ranging from 2.9 mm to 3.3 mm.[24–26] Additionally, the limit of acceptability for the maxillary-mandibular midline deviation has been estimated to be between 2.1 mm and 3.6 mm.[24–26] In view of these results, it can be postulated that midline esthetics was promoted in the treatment group.

Our investigation presents certain shortcomings, mainly related to the sample characteristics. First, it may be argued that the study group included a relatively small number of subjects, which resulted, in some cases, in imprecise estimates as to the associated confidence intervals range from clinically significant to nonsignificant effects. Second, to allow discrimination of the treatment outcome from normal growth, we used historical control data representative of the general Dutch population; however, use of historical controls can be problematic. As factors such as living standards, lifestyles, and nutrition change across time periods, the comparability between the historical and contemporary samples might be questionable. For example, differences in the general level of nutrition, texture of foods, frequency of eating events,[27] and infant feeding methods[28] may affect dental arch development. On the other hand, it would have been unethical to recruit controls by deferring treatment until a later time. Prospective comparative studies of M1 extraction with other Class II subdivision treatment approaches may increase our understanding of the management of asymmetrical Class II malocclusion.

CONCLUSIONS

- Unilateral M1 extraction in Class II subdivision malocclusion may yield favorable long- term occlusal outcomes. Posttreatment changes in midline esthetics and soft tissue profile are considered acceptable.

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REFERENCES

1. Haack DC, Weinstein S. The mechanics of centric and eccentric cervical traction. *Am J Orthod.* 1958;44:346–357.

2. Shroff B, Lindauer SJ, Burstone CJ. Class II subdivision treatment with tip-back moments. *Eur J Orthod*. 1997;19: 93–101.
3. Janson G, Dainesi EA, Henriques JF, de Freitas MR, de Lima KJ. Class II subdivision treatment success rate with symmetric and asymmetrical extraction protocols. *Am J Orthod Dentofacial Orthop*. 2003;124:257–264.
4. Janson G, Branco NC, Morais JF, Freitas MR. Smile attractiveness in patients with Class II division 1 subdivision malocclusions treated with different tooth extraction protocols. *Eur J Orthod*. 2014;36:1–8.
5. Warren DW. Subdivision malocclusions: cracking the riddle. *J Clin Orthod*. 2001;35:93–99.
6. Livas C. Mini-implant anchorage in a unilateral Class II patient. *J Clin Orthod*. 2012;46:293–298.
7. Bock NC, Reiser B, Ruf S. Class II subdivision treatment with the Herbst appliance. *Angle Orthod*. 2013;83:327–333.
8. Cassidy SE, Jackson SR, Turpin DL, Ramsay DS, Spiekerman C, Huang GJ. Classification and treatment of Class II subdivision malocclusions. *Am J Orthod Dentofacial Orthop*. 2014;145:443–445.
9. Mock L, Booij JW. Correction of an Angle Class II/ Subdivision with unilateral maxillary molar extraction. *Inf Orthod Kieferorthop*. 2010;42:63–67.
10. Dibbets JM, Trotman CA, McNamara JA Jr, van der Weele LT, Janosky JE. Multiple linear regression as an analytical tool in cephalometric studies. *Br J Orthod*. 1997;24:61–66.
11. Dibbets JM, Nolte K. Effect of magnification on lateral cephalometric studies. *Am J Orthod Dentofacial Orthop*. 2002;122:196–201.
12. Nolte K, Müller B, Dibbets J. Comparison of linear measurements in cephalometric studies. *J Orofac Orthop*. 2003;64:265–274.
13. Janson G, Carvalho PE, Cançado RH, de Freitas MR, Henriques JF. Cephalometric evaluation of symmetric and asymmetrical extraction treatment for patients with Class II subdivision malocclusions. *Am J Orthod Dentofacial Orthop*. 2007;132:28–35.
14. Stalpers MJ, Booij JW, Bronkhorst EM, Kuijpers-Jagtman AM, Katsaros C. Extraction of maxillary first permanent molars in patients with Class II Division 1 malocclusion. *Am J Orthod Dentofacial Orthop*. 2007;132:316–323.
15. Weyrich C, Lisson JA. The effect of premolar extractions on incisor position and soft tissue profile in patients with Class II, Division 1 malocclusion. *J Orofac Orthop*. 2009;70: 128–138.
16. Scott Conley R, Jernigan C. Soft tissue changes after upper premolar extraction in Class II camouflage therapy. *Angle Orthod*. 2006;76:59–65.
17. Katsaros C. Profile changes following extraction vs. nonextraction orthodontic treatment in a pair of identical twins. *J Orofac Orthop*. 1996;57:56–59.
18. Katsaros C, Ripplinger B, Högel A, Berg R. The influence of extraction versus non-extraction orthodontic treatment on the soft tissue profile. *J Orofac Orthop*. 1996;57:354–365.
19. Booij JW, Goeke J, Bronkhorst EM, Pancherz H, Ruf S, Katsaros C. Overjet correction and space closure mechanisms for Class II treatment by extracting the maxillary first molars. *J Orofac Orthop*. 2011;72:196–203.
20. Demir A, Uysal T, Sari Z, Basciftci FA. Effects of camouflage treatment on dentofacial structures in Class II division 1 mandibular retrognathic patients. *Eur J Orthod*. 2005;27: 524–531.
21. Bishara SE, Jakobsen JR, Hession TJ, Treder JE. Soft tissue profile changes from 5 to 45 years of age. *Am J Orthod Dentofacial Orthop*. 1998;114:698–706.
22. Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. *Eur J Orthod*. 1992;14:180–187.
23. Cassidy SE, Jackson SR, Turpin DL, Ramsay DS, Spiekerman C, Huang GJ. Classification and treatment of Class II subdivision malocclusions. *Am J Orthod Dentofacial Orthop*. 2014;145:443–451.
24. Ker AJ, Chan R, Fields HW, Beck M, Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective: a *computer*-based survey study. *J Am Dent Assoc*. 2008;139: 1318–1327.
25. Chang CA, Fields HW Jr, Beck FM, et al. Smile esthetics from patients' perspectives for faces of varying attractiveness. *Am J Orthod Dentofacial Orthop*. 2011;140:e171–e180.
26. Springer NC, Chang C, Fields HW, et al. Smile esthetics from the layperson's perspective. *Am J Orthod Dentofacial Orthop*. 2011;139:e91–e101.
27. Corruccini RS, Potter RHY, Dahlberg AA. Changing occlusal variation in Pima Amerinds. *Am J Phys Anthrop*. 1983;62: 317–324.
28. Warren JJ, Bishara SE. Comparison of dental arch measurements in the primary dentition between contemporary and historic samples. *Am J Orthod Dentofacial Orthop*. 2001;119:211–215.