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ORIGINAL ARTICLE

Pretreatment dentoskeletal comparison between individuals treated with extractions in the 1970s and in the new millennium

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Abstract

Objective This retrospective study aimed to compare the occlusal and dentoskeletal initial features of patients treated with four first premolar extractions in the 1970s and after 2000.

Materials and methods Group 70′ was composed by 30 subjects with Class I malocclusion (mean age of 12.8 years, 10 male, 20 female) treated in the 1970s with four first premolar extractions and comprehensive orthodontic treatment. Group NM comprised 30 subjects with Class I malocclusion (mean age of 13.4 years, 13 male, 17 female) treated in the new millennium, similarly to Group 70′. Initial dental models and lateral cephalograms were digitized and measured using OrthoAnalyzerTM 3D software and Dolphin Imaging 11.0 software, respectively. Initial occlusal and dentoskeletal features were analyzed and compared. Intergroup comparison was performed using *t* tests ($p < 0.05$). Holm-Bonferroni correction for multiple comparison was applied.

Results Group NM showed significantly greater maxillary and mandibular effective lengths and greater maxillary and mandibular incisor protrusion in comparison with Group 70′. Group NM presented a significantly greater lower anterior facial height. Group NM also showed significantly smaller nasolabial angle and protruded inferior lip.

Conclusion Patients with Class I malocclusion treated with four first premolar extractions in the new millennium present a greater degree of dental and labial protrusion, increased lower anterior facial height, and more acute nasolabial angle compared with patients treated similarly in the 1970s. Greater dental and labial protrusion determines first premolar extractions in the new millennium.

Clinical relevance Despite the decrease of tooth extraction frequency, four first premolar extractions may be justified in cases with severe dental and skeletal protrusions.

Keywords Tooth extraction · Bicuspid · Cephalometry · Class I malocclusion

Introduction

Orthodontics has confronted an extraction vs nonextraction debate in the last hundred years [1–6], which is still ongoing in the twenty-first century [6]. In the beginning of the XX century, Angle proposed nonextraction orthodontic interventions, which were accepted and almost not questioned for over 30 years [5]. However, concerns regarding treatment stability [4] and dental protrusion associated with unsatisfactory facial esthetics [1, 2] reintroduced tooth extraction in the orthodontic field. Extraction treatment had such a great impact in the 1960s, 1970s, and 1980s that more than half of patients presented some tooth removed for orthodontic purposes [7, 8]. Nevertheless, a decrease in tooth extraction frequency was observed subsequently, especially in the new millennium [7–9].

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The decrease of tooth extraction frequency had multifactorial reasons. Excessive incisor uprighting showed a detrimental effect on facial esthetics, leading to a more flattened profile [10–13]. In the second half of the XX century, changes in the perception of an ideal facial esthetics were observed toward a fuller and more protruded dentofacial profile [14, 15]. Additionally, extraction cases showed similar treatment stability compared with nonextraction treatments [16, 17]. The development of orthopedic treatments [18, 19], two-phase interventions [20, 21], interproximal tooth reduction [22, 23], and concerns with temporomandibular disorders [24, 25] also had an influence in the frequency decrease of tooth extraction. Complexity of orthodontic mechanics [26], prolonged treatment time [27], space reopening [28], and an increased degree of external root resorption [29] were also concerns in extraction treatments.

In Class I malocclusion patients, extractions are frequently used in cases with dentoalveolar protrusion and moderate-to-severe crowding [27, 30]. Facial esthetics, labial protrusion, overjet, and overbite are also considered [9, 27, 30]. In the 1970s, the frequency of four first premolar extraction cases started to decrease [7, 8]. At the 1990s, the frequency of extractions was approximately 10%. In the new millennium, frequency of first premolar extraction ranges from 9 to 16% [8, 9].

No previous study has directly compared facial and occlusal initial morphology of Class I patients treated with premolar extractions in the past and currently. Understanding trend changes overtime might support treatment plan decisions and professional confidence. Therefore, the purpose of this study was to compare the initial dentoskeletal features of patients treated with four first premolar extractions in the 1970s and in the New Millennium. The null hypothesis is that subjects treated with extraction in the 1970s and in the new millennium have similar initial features.

Materials and methods

This retrospective study was approved by the institutional Research Ethics Committee of Bauru Dental School, University of São Paulo (process #71638417.9.0000.5417). The primary outcome was dental crowding. Sample size calculation was based on a standard deviation for maxillary irregularity index of 2.6 [31], a minimum intergroup difference of 2 mm, an alpha value of 5%, and a statistical power of 80%. The sample size for each group was 28 subjects.

The sample was selected from the orthodontic records of patients treated between 1973 to 1979 and 2000 to 2013 in the Orthodontic Department of Bauru Dental School, University of São Paulo. Patients' records were organized in a crescent order according to the initial exam date. The inclusion criteria were (1) Class I malocclusion treated with four first premolar extractions, (2) complete and adequate initial records, (3) permanent dentition, and (4) absence of tooth agenesis. Exclusion criteria were (1) patients with history of previous orthodontic treatment and (2) craniofacial anomalies. In the 1970s decade, the frequency of extraction was 54.29%. After the year 2000, the frequency of extractions was 7.47%. In order to address potential bias, Group 70′ selection was performed following this order, evaluating the records from the first case treated in 1973 until the 30th case that met the inclusion criteria. Group NM was selected following the same order, starting with the first patient treated in 2000 until the 30th case that met the inclusion criteria.

Group 70′ was composed by 30 patients (10 male; 20 female) with an initial mean age of 12.8 years (SD = 1.17) treated between 1973 and 1979. In the ages 70′, the decision for extraction was driven predominantly by dental models and cephalometric analysis. Group NM comprised 30 patients (13 male; 17 female) with an initial mean age of 13.4 years (SD = 1.33) treated between 2000 and 2013. After 2000, the decision for extraction was driven by dental models and facial analysis, using the cephalometric analysis as a complementary diagnostic method.

Dental models and lateral cephalograms were used, and all dental models and cephalometric analysis were performed in random order within the same group, so risk of bias was reduced. Initial dental models were digitized using 3D 3Shape R700 scanner (3Shape A/S, Copenhagen, Denmark) and analyzed with OrthoAnalyzerTM 3D software (3Shape A/S, Copenhagen, Denmark). The initial lateral cephalograms were digitized using the Microtek ScanMaker i800 scanner (Santa Fe Springs, CA, USA) and analyzed with Dolphin® 11.5 imaging software (Chatsworth, CA, USA). Magnification factors were corrected according to the cephalostat used in each period, with 6% and 9% (for Group 70′ and NM, respectively). The evaluated cephalometric variables are shown in Figs. 1 and 2.

Both maxillary and mandibular digital dental models were initially oriented with the occlusal plane parallel to the horizontal plane (Fig. 3). The maxillary occlusal plane passed through the mesiopalatal cusp tip of the permanent first molars, bilaterally, and through the mesio-incisal angle of the right central incisor (Fig. 3a). The mandibular occlusal plane passed through the distobuccal cusp tip of the permanent first molars, bilaterally, and through the mesio-incisal angle of the right central incisor (Fig. 3b). The incisor irregularity index [32] was measured on the occlusal view of the digital dental models. The PAR index [33] was evaluated using the physical dental models of each patient.

Error study

All dental model and cephalometric variables were measured twice in 50% of the sample randomly selected after a

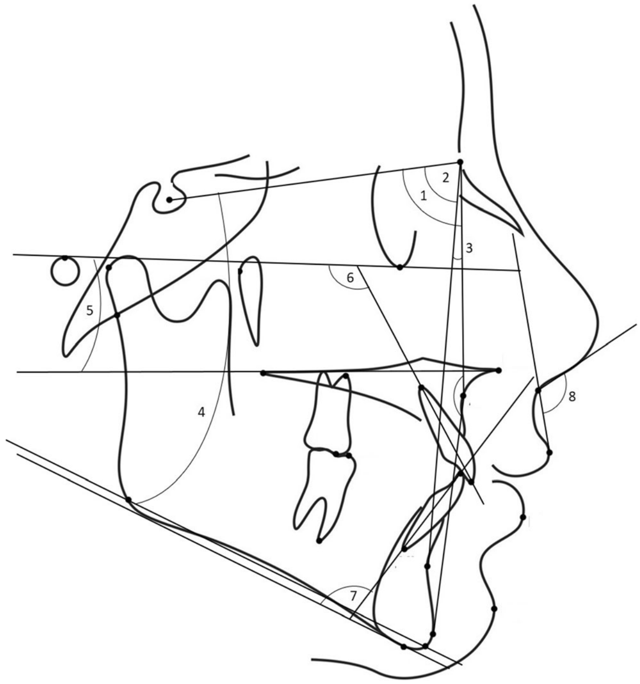

Fig. 1 Cephalometric angular variables measured in the study: 1, SNA; 2, SNB; 3, ANB; 4, SN.GoGn; 5, PP.FH; 6, Mx1.FH; 7, IMPA; 8, nasolabial angle

minimum 30-day interval by one examiner (RN). The intraexaminer reliability was assessed using intraclass correlation coefficient (ICC) [34]; random errors were estimated

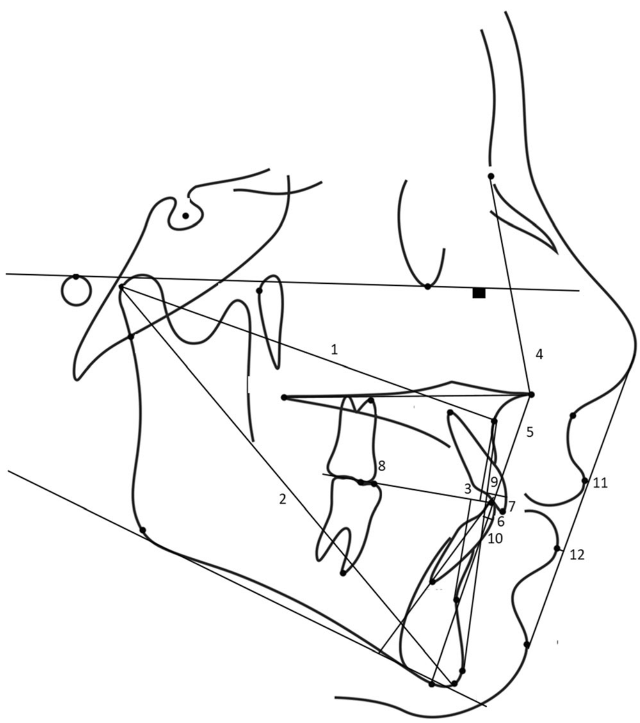

Fig. 2 Cephalometric linear variables measured in the study: 1, Co-A; 2, Co-Gn; 3, Wits; 4, UAFH; 5, LAFH; 6, overjet; 7, overbite; 8, molar relationship; 9, Mx1-APog; 10, Md1-APog; 11, UL-E plane; 12, LL-E plane

using Dahlberg's formula [35] while the systematic errors were calculated with dependent *t* tests, at $P < 0.05$.

Statistical analyses

The variables distribution was verified by the Kolmogorov-Smirnov test. Intergroup comparisons were performed with *t* tests for normally distributed variables and with Mann-Whitney tests for not normally distributed variables, at $P < 0.05$. Holm-Bonferroni correction for multiple comparison was applied. Statistical analyses were performed using Statistica software (Statistica for Windows version 11.0; StatSoft Inc., Tulsa, OK).

Results

The ICC values varied from 0.849 to 0.989, showing excellent measurement reproducibility. The random errors ranged from 0.47 to 2.20 (maxillary irregularity index and PAR Index, respectively) for the dental model variables (Table 1). The random errors ranged from 0.35 mm to 1.34 mm (molar relationship and Co-A, respectively) for cephalometric linear variables and from 0.54 to 2.88 (ANB and nasolabial angle, respectively) for the angular measurements. No significant systematic errors were found.

The groups were comparable regarding initial age and sex distribution (Table 2).

The dental model analysis showed similar dental crowding and similar initial occlusal malocclusion severity in both groups (Table 3).

Group NM presented significantly greater maxillary and mandibular effective lengths and labial tipping and protrusion of the maxillary and mandibular incisors than Group 70′ (Table 3). Group NM presented significantly greater lower anterior facial height in comparison with Group 70′.

Group NM also displayed significantly smaller nasolabial angle and more protruded lower lip than Group 70′ (Table 3).

Discussion

Accuracy and reproducibility of cephalometric and digital dental model analysis are well documented [36]. Digital lateral cephalograms and dental models have been widely used in orthodontic research [36–38]. Our study showed adequate reproducibility within acceptable limits, corroborating previous studies [30, 39–41] (Table 1).

Class I malocclusion associated with dental crowding is commonly seen in the orthodontic practice [42], and crowding severity is considered a determinant factor in extraction decision [30]. Previous studies reported low self-esteem associated with severe crowding [43]. In this study, no intergroup

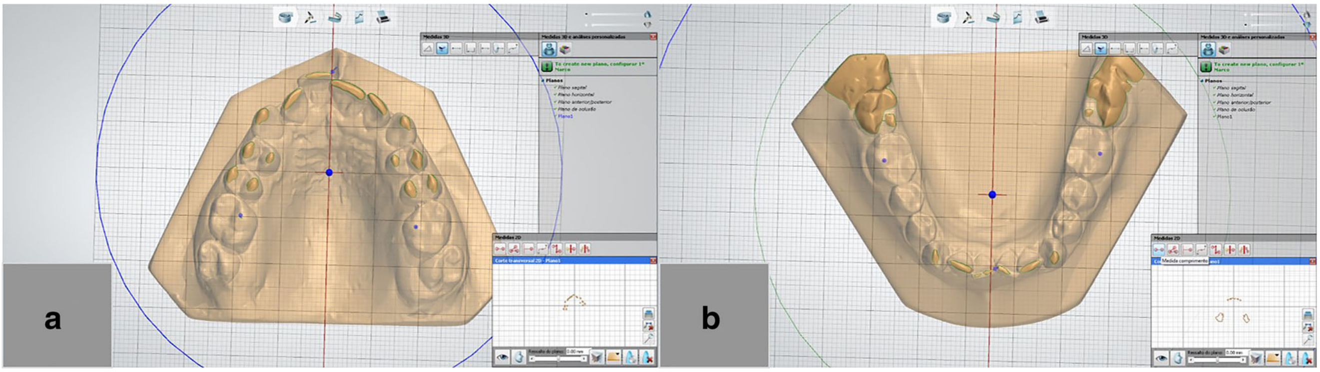

Fig. 3 Maxillary (**a**) and mandibular (**b**) dental model orientation for measuring incisor irregularity index

Table 1 Error study (Dahlberg's formula and paired *t* tests)

Measurement	Measurement 1		Measurement 2		ICC	Dahlberg	*p*
	Mean	SD	Mean	SD			
Dental model analysis							
Maxillary incisor irregularity Index (mm)	7.90	4.35	8.04	4.18	0.987	0.47	0.278
Mandibular incisor irregularity Index (mm)	7.91	4.66	8.00	4.70	0.989	0.48	0.463
PAR Index	23.97	7.93	23.67	7.31	0.914	2.20	0.606
Cephalometric analysis							
Maxillary skeletal components							
SNA (°)	80.95	4.16	81.30	4.39	0.966	0.78	0.085
Co-A (mm)	82.74	3.45	82.49	3.53	0.849	1.34	0.478
Mandibular skeletal components							
SNB (°)	77.39	3.71	77.65	3.74	0.975	0.58	0.073
Co-Gn (mm)	110.81	5.38	110.23	5.02	0.943	1.23	0.067
Maxillomandibular relationship							
ANB (°)	3.57	2.02	3.64	1.87	0.921	0.54	0.608
Wits (mm)	0.36	2.34	0.32	2.25	0.894	0.74	0.824
Vertical component							
SN.GoGn (°)	35.52	5.19	35.32	5.09	0.970	0.88	0.396
PP.FH (°)	− 2.34	3.71	− 2.38	3.46	0.941	0.86	0.849
UAFH (mm)	48.64	2.55	48.82	2.59	0.941	0.61	0.271
LAFH (mm)	64.31	4.94	64.60	4.88	0.986	0.57	0.051
Interdental							
Overjet (mm)	3.75	1.51	3.62	1.48	0.934	0.38	0.186
Overbite (mm)	1.56	2.21	1.66	2.07	0.968	0.37	0.293
Molar Relationship (mm)	− 1.01	1.09	− 0.93	1.07	0.892	0.35	0.363
Maxillary dentoalveolar components							
Mx1.FH (°)	116.73	7.25	117.62	7.38	0.924	1.99	0.083
Mx1-APog (mm)	8.49	3.03	8.35	3.13	0.957	0.63	0.411
Mandibular dentoalveolar components							
IMPA (°)	95.35	8.51	94.68	8.27	0.965	1.55	0.093
Md1-APog (mm)	4.84	3.21	4.68	3.10	0.983	0.41	0.121
Soft tissue profile							
Nasolabial angle (°)	108.53	8.72	109.26	8.72	0.888	2.88	0.330
UL-E plane (mm)	− 1.93	2.23	− 2.15	2.32	0.951	0.50	0.077
LL-E plane (mm)	1.33	2.87	1.50	2.90	0.939	0.70	0.376

Table 2 Intergroup comparisons for initial age and sex distribution (*T* and Chi-square tests)

Variable		Group 70′ (*n* = 30)		Group NM (*n* = 30)		
		Mean	SD	Mean	SD	*P*
Initial age (years)		12.84	1.17	13.40	1.33	0.093
Sex	Male	10		13		0.425
	Female	20		17		

differences were found for the initial amount of maxillary and mandibular crowding (Table 3). Both groups showed moderate-to-severe initial dental crowding. Initial occlusal malocclusion severity can also determine the need for tooth extraction. The greater the occlusal malocclusion severity, the greater the probability that tooth extraction will be needed [44]. In this study, both groups presented similar initial occlusal malocclusion severities. Therefore, over the last 30 years, no differences were found for severity of both anterior dental crowding and initial occlusal malocclusion severity in patients treated with four premolar extractions.

Table 3 Intergroup comparisons for dental models and cephalometric variables (*t* test)

Variables	Group 70′		Group NM		Estimate difference		
	Mean	SD	Mean	SD	Mean	CI 95%	*P*
Dental model analysis							
Maxillary incisor Irregularity index	7.42	3.36	8.47	5.52	− 1.05	− 3.41 to 1.31	0.376
Mandibular incisor Irregularity index	8.04	4.26	8.22	5.61	− 0.18	− 2.75 to 2.40	0.892
PAR index	23.93	7.99	20.10	8.85	3.83	− 0.52 to 8.19	0.083
Cephalometric analysis							
Maxillary skeletal components							
SNA	80.67	4.48	82.77	4.38	− 2.10	− 4.39 to 0.19	0.071
Co-A	80.43	3.55	82.58	3.14	− 2.15	− 3.88 to 0.41	0.016*
Mandibular skeletal components							
SNB	77.34	3.69	78.97	4.41	− 1.63	− 3.72 to 0.47	0.126
Co-Gn	107.61	5.35	111.84	5.55	− 4.23	− 7.04 to − 1.40	0.004*
Maxillomandibular relationship							
ANB	3.32	2.10	3.79	2.38	− 0.47	− 1.63 to 0.69	0.421
Wits	0.37	2.12	−0.29	2.68	0.66	− 0.58 to 1.92	0.288
Vertical component							
SNGoGn	35.04	4.45	33.82	6.41	1.22	− 1.63 to 4.04	0.394
PP.FH	− 1.71	3.07	− 3.18	3.79	1.47	− 0.31 to 3.26	0.103
UAFH	47.13	2.77	48.00	3.69	− 0.87	− 2.56 to 0.81	0.304
LAFH	61.99	4.71	64.71	4.22	− 2.71	− 5.02 to − 0.39	0.022*
Interdental							
Overjet	4.28	2.20	3.50	1.92	0.78	− 0.29 to 1.85	0.150
Overbite	1.61	1.97	1.25	1.77	0.36	− 0.60 to 1.33	0.456
Molar relationship	− 0.52	1.26	− 0.79	1.03	0.27	− 0.32 to 0.87	0.357
Maxillary dentoalveolar components							
Mx1.FH	115.93	7.43	120.23	6.84	− 4.30	− 7.99 to − 0.60	0.023*
Mx1-APog	7.87	2.62	9.79	2.66	− 1.92	− 3.28 to − 0.55	0.006*
Mandibular dentoalveolar components							
IMPA	93.11	6.55	99.53	8.02	− 6.42	− 10.20 to − 2.63	0.001*
Md1-APog	3.69	2.74	6.35	2.66	− 2.66	− 4.05 to − 1.25	< 0.001*
Soft tissue profile							
Nasolabial angle	111.08	9.23	102.01	9.74	9.07	4.15 to 13.97	< 0.001*
UL-E plane	− 1.77	2.23	−0.83	2.48	− 0.94	− 2.16 to 0.28	0.129
LL-E plane	0.66	2.61	2.62	2.33	− 1.96	− 3.27 to 6.68	0.003*

*Statistically significant after applying Holm-Bonferroni correction

Greater maxillary and mandibular effective lengths and dental protrusion was found in patients treated with extractions in the new millennium in comparison with patients treated in the past (Table 3, Figs. 4 and 5). These results corroborate previous studies that indicated four first premolar extractions when an important biprotrusion was present, reporting straightening and improvement of the facial profile [10, 11, 27, 45]. Esthetic evaluation associated low self-esteem with severe protrusion [43] and showed that straight profiles have been considered the most attractive [46–48]. Despite the modern esthetic trend toward a fuller and protrusive profile [14, 15], severe biprotrusion and excessive convex profiles are considered to impair facial esthetics [47, 48]. In other words, in the new millennium four premolar extractions were performed in more biprotrusive patients. Conversely, in the 1970s decade, four premolar extractions were performed even when a slight degree of incisor protrusion was present, probably, more often leading to a flattened facial profile. Development of skeletal anchorage devices facilitated treatment of patients with straight profiles indicated to four first premolar extractions, allowing anchorage loss in order to maintain an esthetic facial profile [49, 50].

No intergroup differences in facial growth pattern were found (Table 3). Both groups showed a predominant hyperdivergent growth pattern. These findings were expected considering that previous studies have indicated four first premolar extractions in patients with hyperdivergent pattern [51–53]. Control of the vertical dimension was thought to occur by counterclockwise rotation of the mandible, through forward movement of the posterior teeth [51–53]. Greater increase in LAFH has been observed after nonextraction than in extraction treatment [51, 54, 55]. Our results are in accordance with indication of four first premolar extractions predominantly in a hyperdivergent pattern, both in the 1970s and in the new millennium. Group NM showed increased LAFH compared with Group 70′ (Table 3). This may be explained by the greater effective maxillary and mandibular lengths observed in group NM.

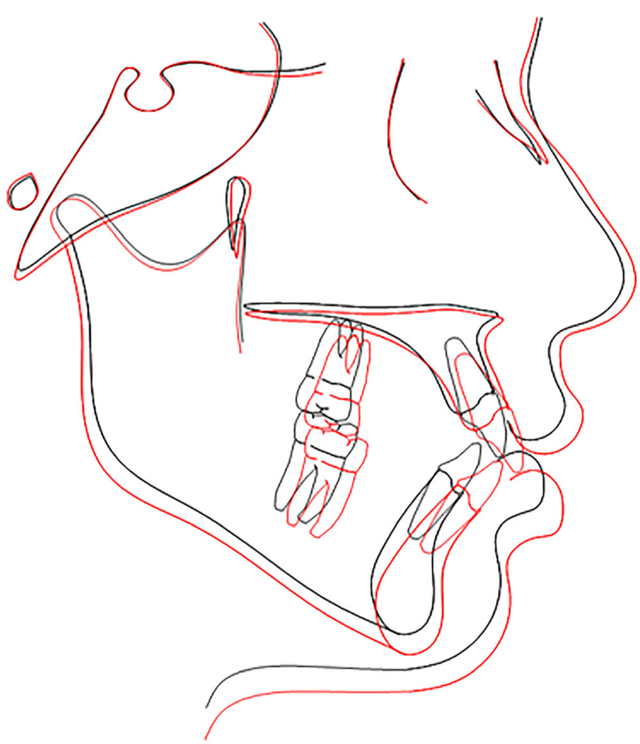

Fig. 4 Superimposition on SN, centered at S, of the average cephalometric tracings of both groups. Black for Group 70′ and red for Group NM

The soft tissue evaluation showed more acute nasolabial angle and more protruded lower lip in Group NM compared with Group 70′ (Table 3, Figs. 4 and 5). These differences reflect the abovementioned greater dental protrusion in group NM. Soft tissue features have been considered a determinant factor for extraction decision [27, 30, 45]. Recent studies have indicated four first premolar extractions in patients with increased lip prominence [27, 30]. Premolar extractions, followed by anterior retraction, lead to more pleasing profiles in patients with protruded lips [30, 56]. Lip response to anterior teeth retraction shows great variance and depends on inherent characteristics of each individual as ethnic background, lip thickness and quality of the lip musculature [52, 56]. On other hand, in borderline patients, premolar extractions have not compromised the facial profile [57]. Lip retraction is expected in borderline patients after extraction; however, these changes are small and considered clinically irrelevant [57]. Despite the variance of lip-to-incisor-retraction correlation [56], improvement of the facial profile in biprotrusive patients is expected after four first premolar extractions [27, 56].

In summary, four premolar extractions are currently indicated in cases coupling severe dental crowding, significant incisor/lip protrusion, and predominant vertical growth pattern. In the past, a great number of extractions were performed in cases with mild degrees of mandibular incisor protrusion, just to fit a given cephalometric pattern [2, 58–60]. These evolutional trends are in consonance with the facial profile preferences and the decrease of tooth extractions over the last decades [7–9, 12–15, 27].

Limitations

Because of the limitations of having a sample composed by patients treated in a single center, future studies should consider multicenter patients in order to confirm these tendencies.

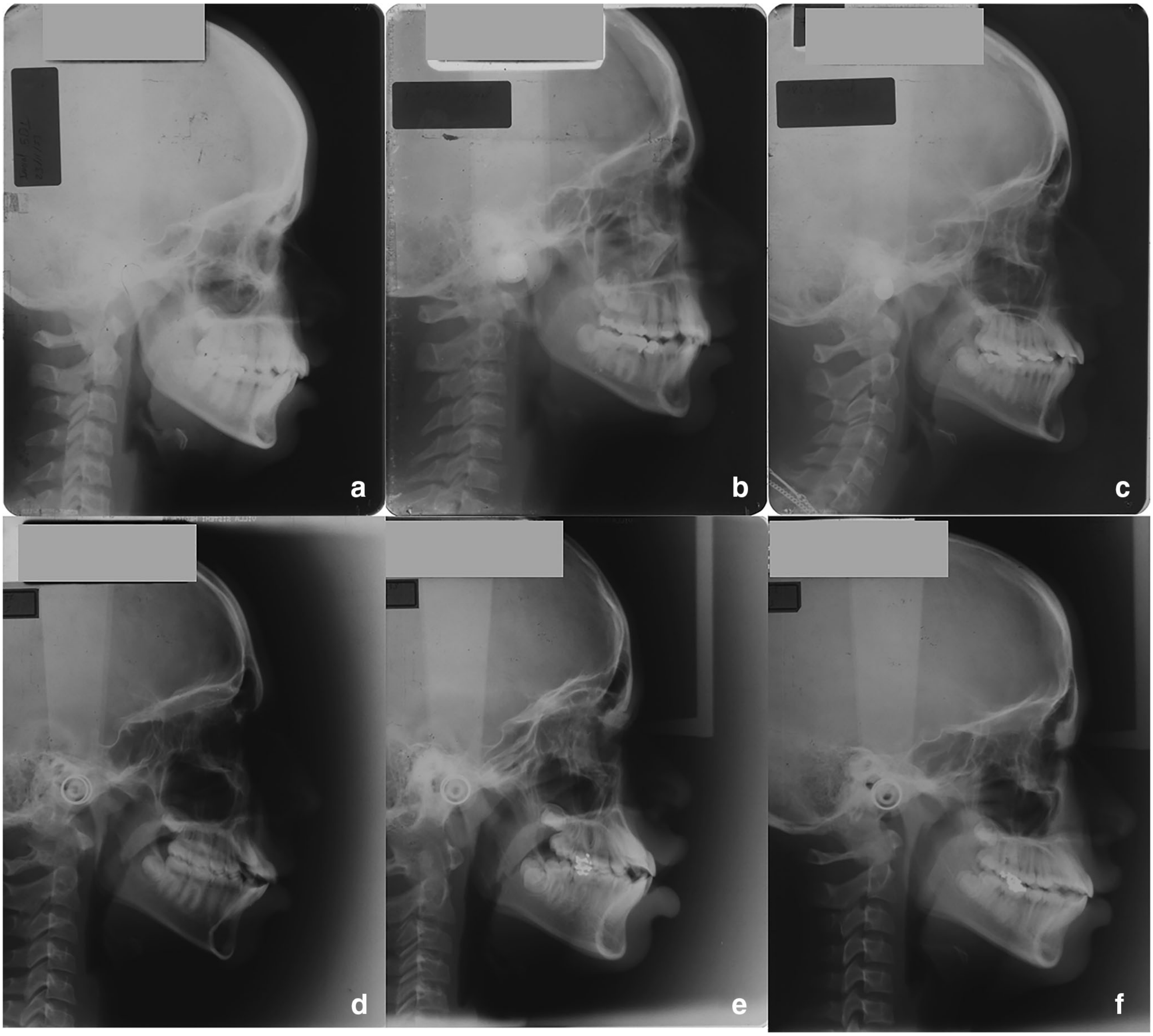

Fig. 5 Example of lateral cephalograms of Group 70′ (**a** to **c**) and Group NM (**d** to **f**). Greater incisor biprotrusion in group NM is evident

Conclusions

The null hypothesis was rejected because patients with Class I malocclusion treated with four first premolar extractions in the new millennium present the following:

- A significantly greater dental and labial protrusion
- A significantly greater lower anterior facial height and smaller nasolabial angle compared with patients treated in the 1970s

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval In this article, all procedures involving human participants were in accordance with the ethical standards of the Research Ethics Committee of Bauru Dental Scooll, University of São Paulo (#71638417.9.0000.5417).

Informed consent Informed consent was obtained from all individual participants included in the study.

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