Physiologic drift of the mandibular dentition following first premolar extractions

S.G. Papandreas, MS, DDS; P.H. Buschang, PhD; R.G. Alexander, MS, DDS;
D.B. Kennedy, MS, DDS; I. Koyama, DDS, DDSc

The dental profession has long recognized a need for extracting premolars when supporting bone is insufficient for the amount of tooth structure present. Assuming that extraction is deemed necessary, decisions are limited to determining when to extract and when to initiate mechanotherapy.

Traditionally, the extraction of teeth has been immediately followed by appliance therapy. This practice, which is still the most common approach, was proposed to prevent adverse and unwanted tooth movement, especially of those teeth adjacent to the extraction sites.[1] However, initiating therapy immediately following extraction may not be necessary.[2,3] There are, after all, potential benefits from a period of physiologic dental drift post-extraction, as first proposed by Bourdet.[4] The benefits include better occlusal relationships, increased dentoalveolar support, and a shorter period of full appliance therapy owing to spontaneous realignment of the dentition.[5-9]

While the concept of physiologic drift, commonly referred to as "driftodontics", following first premolar extractions has been gaining acceptance in the orthodontic community, the exact nature and amount of drift has not been adequately documented. There are also no guidelines as to when drift should be allowed to occur. The purpose of this study was to quantify physiologic drift of the untreated mandibular dentition following extractions of the four first premolars during the mixed and permanent dentition stages.

Abstract

A retrospective study of two groups of patients was conducted to evaluate the physiologic drift, or "driftodontics", of the mandibular teeth following the extraction of four first premolars. Group 1 included 32 patients who underwent early extraction in the mixed dentition stage at a mean age of 10.4 years; they were followed for approximately 2.5 years postextraction. Group 2 included 20 patients whose premolars were extracted after the permanent dentition had fully erupted. Their mean age at the time of extraction was 14.2 years, followed by a 0.8 year observation period. Except for the extractions, no other mandibular therapy was rendered. The results show no differences in rates of molar movements between groups. The molar apex moved mesially approximately 0.6 mm/yr; the molar cusp moved mesially approximately 1.2 mm/yr. In contrast, there were marked group differences in movements of the mandibular incisors and canines; rates of change were significantly greater in Group 2 than in Group 1. The canines drifted laterally and distally into the extraction sites while the incisors became more upright over basal bone and less crowded. Incisor irregularity decreased 1.3 mm/yr in Group 1 and 5.5 mm/yr in Group 2. The group differences in amounts of tooth movement were accounted for by changes in incisor crowding.

Key Words

Physiological drift • Extraction therapy • Cephalometrics • Growth • Mandible

Submitted: February 1992 **Revised and accepted for publication:** August 1992

Table 1
Cephalometric angles and distances

Measure	Description
Anterior - Posterior Relations	
I1/MP (deg)	Lower incisor angulation to the mandibular plane (gonion-menton)
$I1_e$-ARP (mm)	Lower incisal edge distance to the anterior reference point
$I1_a$-ARP (mm)	Lower incisor apex distance to the anterior reference point
M1/RP (deg)	Lower first molar angulation to the reference plane
$M1_c$-ARP (mm)	Lower first molar mesiobuccal cusp distance to the anterior reference point
$M1_a$-ARP (mm)	Lower first molar mesial root apex to the anterior reference point
OJ (mm)	Overjet measured as the horizontal distance between the upper and lower incisor edges parallel with the occlusal plane.
Vertical Relations	
$I1_e$-Me (mm)	Lower incisal edge distance to menton
$M1_c$-MP (mm)	Lower first molar mesiobuccal cusp distance to the mandibular plane
OB (mm)	Overbite measured as the vertical distance between the upper and lower incisal edges perpendicular with the occlusal plane
S-N/MP (deg)	Mandibular plane angulation to the sella - nasion line

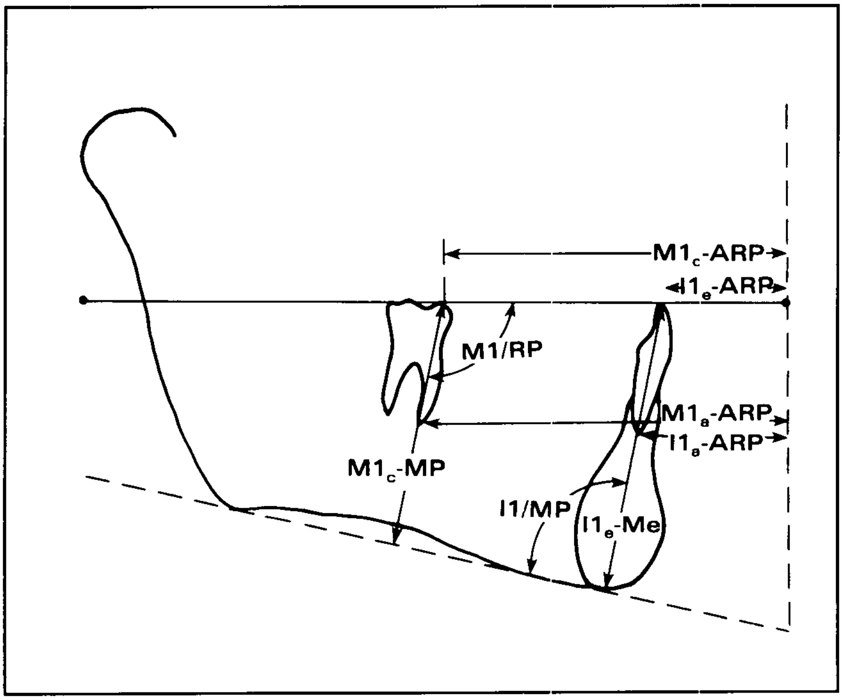

Figure 1

Figure 1 Cephalometric distances and angles. Horizontal movements evaluated relative to anterior reference point (ARP).

Materials and methods

Two samples of patients, treated by two different orthodontists, were selected using the following criteria:

1. No prior orthodontic treatment.
2. Skeletal and dental class I malocclusion with mandibular arch length deficiency.
3. Extraction of the four first premolars followed by a period of drift.

The early extraction sample (Group 1) included 32 patients (19 females and 13 males), 40% of North American ancestry and 60% of Asian ancestry. Treatment included extraction of the four first premolars in the late mixed dentition stage (premolars had just emerged) at approximately 10.4 years of age (SD = 1.1 years). The observation period following extraction was approximately 2.5 years (SD = 0.8 years).

The late extraction sample (Group 2) included 20 patients (16 females and 4 males) of Asian ancestry. Extractions of the four first premolars were performed after the second molars had fully emerged. The maxillary arch was treated using light wires and extraoral cervical pull headgear. The inner facebow was routinely overexpanded. The mean age at pretreatment was 14.2 years (SD = 2.5 years), followed by a observation period of 0.8 years (SD = 0.3 years).

Pre- and post-treatment lateral cephalograms and dental casts were analyzed. The cephalograms were randomly traced by one operator. A reference line with arbitrary anterior and posterior points was drawn tangent to the mesio-buccal cusp of the mandibular first molar and the mandibular incisal edge on the pre-extraction tracing. Using stable anatomical reference structures described by Björk and Skieller,[10] the post-extraction mandible was superimposed on the pre-extraction mandible. The reference line and points were then transferred to the post-extraction tracing; they served as a stable reference for evaluating horizontal and vertical changes of the landmarks.

Sixteen additional cephalometric landmarks were identified on each tracing. Eleven angles and distances were calculated (Figure 1; Table 1). The mandibular plane was defined by the landmarks gonion and menton. The dental casts were measured using electronic calipers accurate to 0.01 mm. Arch depth (AD) was measured from the midpoint of the most labial aspect of the central incisors to the point bisecting the line connecting the mesial contacts of the first permanent molars. The irregularity index (IRREG) represented the sum of the five distances between adjacent contact points of the six anterior teeth.[11] Intercanine width (ICW) was measured between the cusp tips or estimated cusp tips when wear facets were present. No measurements were taken if the permanent canines had not erupted. First permanent intermolar width (IMW) was measured between the central pits or estimated central pits in the case of occlusal sealants or restorations.

To evaluate reliability, measurements of 15 randomly chosen cephalograms and models were replicated. Systematic error was not significant for any of the measures. Method error[12] ranged between 0.18 mm and 0.63 mm for the linear measurements, and between 0.58° and 0.84° for the angular measures.

Due to individual and group differences in duration between the pre-and-post extraction records, all measures were adjusted to annual rates of change $[(Var_{T2} - Var_{T1})/(Age_{T2} - Age_{T1})]$. The adjustment assumes continuity of pattern; on that basis it is possible to more accurately compare changes and produce meaningful summary statistics. Measures showing significant skewness and/or kurtosis were normalized through logarithmic transformation. Two-way analyses of variance were used to evaluate sex and group differences.

For selected variables, the cephalometric and dental changes were compared with middle to upper socio-economic class controls of Northern European ancestry.[13,14] The control sample provides a baseline to compare changes of treated and untreated children. For each subject, age- and sex-specific z-scores were calculated to allow males and females of different ages to be combined for analysis. Z-scores express each individual's deviation from the control mean in standard deviation units. Although size differences between the control and experimental subjects might be anticipated, little or no difference in actual changes might be expected. Paired t-tests were used to compare pre-and post-extraction z-scores; significant differences were interpreted as treatment effects.

Table 2
Pre- and post-extraction lower incisor angulation and irregularity index

Parameter	ANOVA F	ANOVA Sig	Group	N	Mean	Standard Deviation
Pre-extraction						
I1/MP	16.11	<0.001	1	32	88.57	8.29
			2	20	97.06	5.73
IRREG	7.38	0.011	1	32	5.45	2.72
			2	20	8.27	2.79
Post-extraction						
I1/MP	6.89	0.011	1	32	84.70	9.79
			2	20	91.23	6.61
IRREG	6.55	0.016	1	32	3.29	1.61
			2	20	4.17	1.66

Results

Analyses of variance (Table 2) demonstrated significant pre- and post-extraction group differences in mandibular incisor angulation and irregularity. As expected, the late extraction group displayed greater proclination and irregularity of the incisors than the early extraction group both before and after extraction therapy.

Sex differences in annual rates of change during the observation period were not statistically significant (Table 3). Group differences were also insignificant for eight of the fifteen measurements. Consistently, anterior-posterior changes in molar position were not statistically significant between groups. Table 4 shows that the molars tipped mesially approximately 1.9°/yr; the molar cusp and apex moved mesially 1.2 mm/yr and 0.6 mm/yr, respectively (Figure 2). There was an increase of approximately 0.5 mm/yr in the vertical distance between the mandibular plane and both the molar cusp and incisor tip . The mandibular plane angle decreased approximately 0.3 degrees per year. Movements of the incisor apex and changes in overjet were not statistically significant over the drift period.

In contrast to the molars, the incisors displayed statistically significant group differences (Table 5). The rate of lower incisor retroinclination was approximately four times greater for the late extraction group than for the early extraction group (Figure 3). This difference can be attributed to distal movements of the incisal edge. The late extraction group also showed significantly greater

Table 3
Analyses of variance evaluating sex and group differences

Variable	Residual DF	Sex Effect DF	Sex Effect F	Sex Effect Prob	Group Effect DF	Group Effect F	Group Effect Prob
Anterior - Posterior Changes							
I1/MP	45	1	0.12	0.728	1	19.38	<0.001
$I1_e$-ARP	45	1	0.04	0.851	1	19.24	<0.001
$I1_a$-ARP	45	1	1.54	0.222	1	0.28	0.600
M1/RP	45	1	0.78	0.382	1	0.84	0.363
$M1_c$-ARP	45	1	3.47	0.069	1	1.98	0.166
$M1_a$-ARP	47	1	0.24	0.624	1	0.87	0.355
OJ	47	1	1.29	0.261	1	0.00	0.949
AD	48	1	0.04	0.835	1	24.95	<0.001
IRREG	27	1	3.00	0.094	1	29.60	<0.001
Vertical Changes							
$I1_e$-Me	45	1	0.27	0.606	1	0.75	0.391
$M1_c$-MP	47	1	2.44	0.125	1	0.01	0.927
OB	47	1	0.10	0.759	1	21.31	<0.001
S-N/MP	47	1	0.97	0.330	1	0.22	0.643
Transverse Changes							
ICW	48	1	0.31	0.579	1	10.54	0.002
IMW	48	1	0.35	0.556	1	13.40	0.001

Table 4
Yearly increments during the drift period for variables showing no significant group differences

Variable	Unit	N	Mean	SD
Anterior-Posterior Changes				
$I1_a$-ARP	mm/yr	51	-0.12	0.79
M1/RP	deg/yr	52	1.90	3.63
$M1_c$-ARP	mm/yr	52	-1.19	1.31
$M1_a$-ARP	mm/yr	51	-0.58	1.21
OJ	mm/yr	52	-0.08	1.22
Vertical Changes				
$I1_e$-Me	mm/yr	52	0.52	0.61
$M1_c$-MP	mm/yr	52	0.55	0.96
S-N/MP	mm/yr	52	-0.30	1.81

Table 5
Yearly increments during the drift period for variables showing a significant group difference

Variable	Units	Group	N	Mean	SD
Anterior-Posterior Relations					
I1/MP	deg/yr	1	32	-1.76	2.42
		2	20	-8.08	6.71
$I1_e$-ARP	mm/yr	1	32	0.39	0.47
		2	20	2.53	2.36
IRREG	mm/yr	1	32	-1.33	1.26
		2	20	-5.54	4.04
AD	mm/yr	1	32	-1.65	0.60
		2	20	-3.33	1.64
Vertical Relations					
OB	mm/yr	1	32	0.34	0.84
	mm/yr	2	20	2.30	1.68
Transverse Relations					
ICW	mm/yr	1	32	0.59	0.78
		2	20	1.69	1.68
IMW	mm/yr	1	32	-0.77	0.55
		2	20	-0.13	0.67

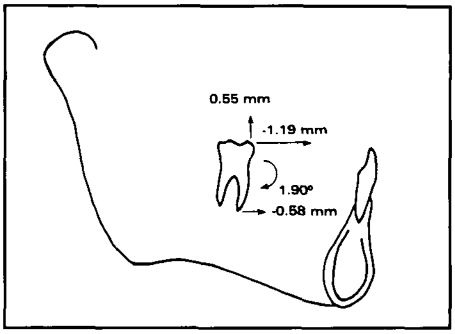

Figure 2

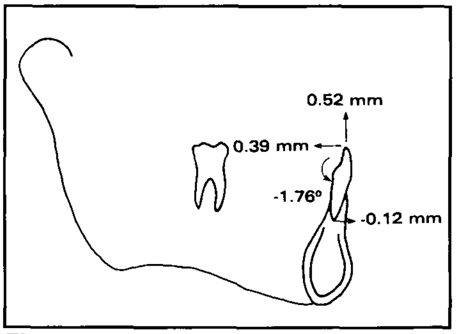

Figure 3A

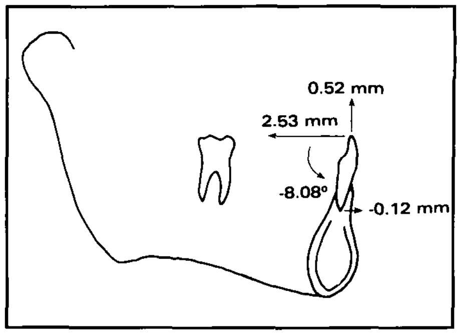

Figure 3B

Figure 2
Annual changes in molar position following early or late premolar extraction.

Figure 3A-B
Annual changes in incisal position for the early (A) and late (B) premolar extraction groups.

increase in overbite and a more pronounced decrease in incisor irregularity. Arch depth changes were approximately twice as great and intercanine width increased roughly three times as fast for Group 2 than for Group 1 (Figure 4). Finally, the late extraction group showed significantly less decrease in intermolar width than the early extraction group.

Analyses of covariance showed that the observed changes in the irregularity index accounted for all but one of the group differences. In other words, most of the variation between groups was directly related to individual changes in irregularity during the drift period. As expected, changes in irregularity did not account for group differences in intermolar width.

Table 6 evaluates differences between the pre- and post-extraction z-scores. Vertical changes of the lower incisal edge and, particularly, the lower first molar cusp were significantly greater than expected. Z-scores for lower incisor angulation, arch depth, intercanine width and intermolar width also indicated significant treatment effects. The mandibular plane showed no statistically significant differences, suggesting normal growth changes unaffected by treatment. Intermolar width in the late extraction group also followed a normal pattern of change.

Discussion

Group differences before premolar extraction reflect, primarily, the progressive development of malocclusion and the treatment approaches of the two orthodontists. Importantly, the observed group differences are accounted for by reductions in the irregularity index. Since the change in the irregularity index was significantly correlated with pretreatment irregularity (R=0.74), it follows that the initial incisor crowding played a major role in defining group differences.

The rationale for first premolar extraction during the mixed stage of dental development is to maintain the functional position of the dentition and avoid insults to supporting alveolar bone.[15] This approach is based on the conservation of alveolar bone height, since it has been previously shown that there is a loss of bone height when the arch length deficiency is permitted to fully express itself in the permanent dentition.[16] If the displacement of teeth from their ideal position over the supporting basal bone produces a loss in alveolar bone height, it follows that early extraction of permanent and primary teeth may allow the remaining dentition to erupt into a less crowded arch and, thereby, maintain maximal alveolar support. Maximum dentoalveolar support may also be a factor in determining stability.[17]

The treatment approach for Group 2 was to postpone the extraction decision as long as possible. This allows the practitioner to exhaust other treatment options which may obviate the need for extraction. Orthodontic brackets were once placed with metal bands completely encircling the tooth, an approach requiring additional arch length and often dictating extraction in borderline cases. Orthodontic advances have permitted an increasing number of malocclusions to be treated nonextraction. The advent of brackets bonded to the labial tooth surfaces has permitted many borderline cases to be treated nonextraction; the introduction of flexible rectangular archwires and the advent of slenderizing have further decreased the need for extraction.

Orthodontists traditionaly believed in the immediate placement of orthodontic appliances following premolar extractions to minimize adverse mesial drift of the posterior teeth. As expected, relatively greater mesial molar movements are associated with second premolar extraction than first premolar extraction.[18,19] While Robertson, Cavina and Moss[20] found that 91% of the first premolar extraction space was taken up by the mesial movement of the molars, most studies report substantially less movement of the posterior teeth. Weber[19] showed that approximately one-third of the space closure following first premolar extraction is taken up by mesial molar

Figure 4
Annual changes in arch width following early (A) and late (B) premolar extraction groups.

Figure 5
Pre-and post-treatment occlusal views of early (A) and late (B) extraction therapy, showing spontaneous realignment of the dentition.

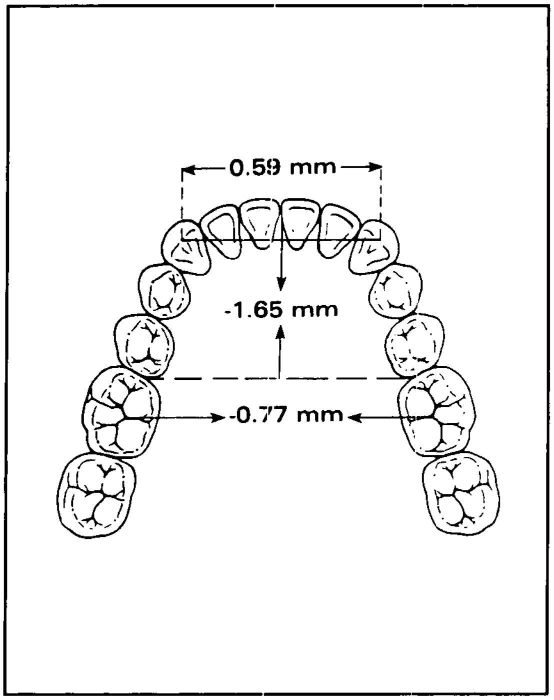

Figure 4A

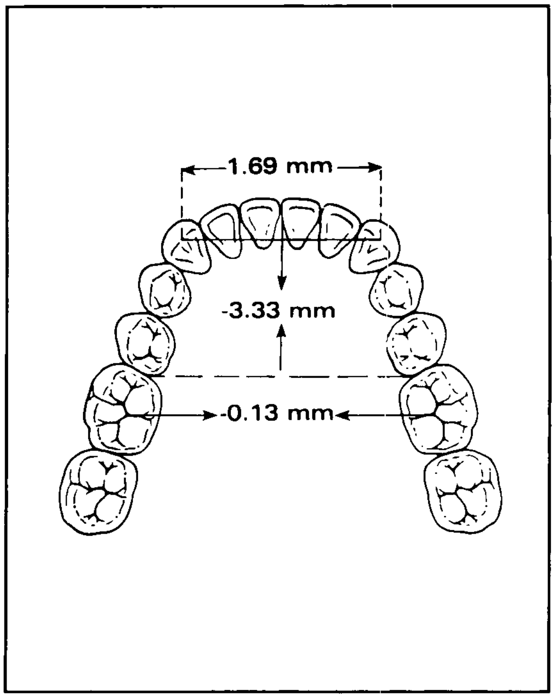

Figure 4B

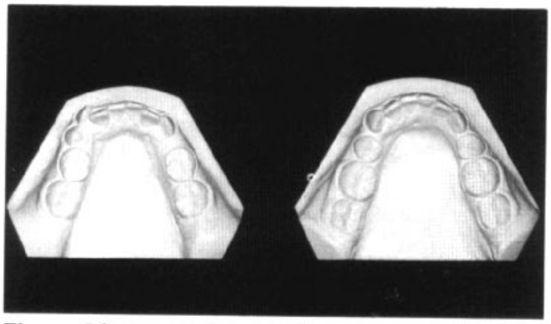

Figure 5A

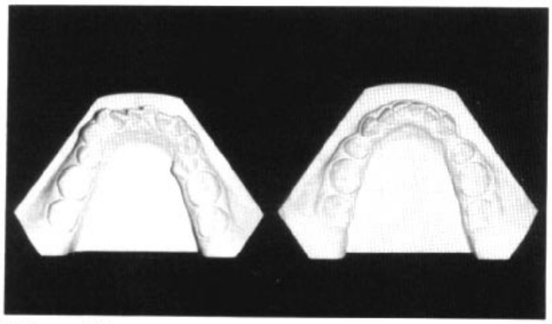

Figure 5B

movement; two-thirds is accounted for by distal canine movements. Glauser[21] reported that approximately 76% of extraction space is taken up by canine movement. Berg and Gebauer[22] attributed 80% of the space reduction to distal drifting of the canines.

Results of the present study also support more limited mesial movement of the posterior dentition. The total molar movement of the early extraction group was approximately 3 mm at the cusp and 1.5 mm at the apex, most of which may be associated with normal loss of leeway space. The late extraction group showed approximately 1 mm and 0.5 mm mesial movement of the cusp and apex, respectively. Since most spontaneous closure of extraction sites occur during the first six months,[8] the observation period of the late extraction group was sufficient to capture most of the changes that might be expected to occur.

The only molar measurement that showed a significant group difference was intermolar width. The width changes observed for the early extraction Group 1 compare favorably with the 0.6 mm/yr decrease reported by Kinne[22] over a similar observation period and age span. The late extraction group, which underwent extraoral cervical pull headgear therapy with the inner bow routinely over-expanded to increase inter-molar width showed substantially less decrease in intermolar width. Assuming that intercuspal contact between the maxillary and mandibular molars was maintained, expected decreases in mandibular intermolar width were probably minimized by the maxillary therapy.

Changes in the anterior arch segment exhibited a number of important group differences. The incisors retroclined about a center of rotation located close to the root apex. The incisor's center of resistance moved slightly up and back, especially for the late extraction group, which showed 4.5 times more retroclination than the early extraction group. Glauser[21] reported a 5.8° change over 40 months of treatment, which compares favorably with the changes observed for the early extraction group. Changes in the AP position of the apex and the vertical movement of the incisal edge were similar in the two groups. While overjet changes showed no significant group differences, increase in overbite was substantially greater for Group 2 than for Group 1. The minor increase in overbite for Group 1 closely agrees with amounts previously cited.[1,20,23] Interestingly, both the incisal tip and molar cusp showed vertical increases of approximately 0.5 mm/yr. Assuming normal remodeling changes of the lower border (deposition anteriorly and resorption posteriorly), there must have been greater molar than incisor eruption taking place. Greater molar eruption is also supported by the z-score comparison with control samples.

Arch depth of Group 2 decreased at twice the rate observed for Group 1. Again, Kinne[22] produced results similar to those of the early extraction group, most of the decrease in arch depth in that group was due to mesial movement of the molar. Most of the decrease in arch depth of the late extraction group was due to distal movement of incisor tip associated with uprighting.

Changes in intercanine width as a result of physiologic drift after late extraction were previously evaluated by Berg and Gebauer,[24] who showed a 0.9 mm increase in intercanine width over the first 6 months of therapy. This rate is similar to the 1.7 mm/yr increase observed for the late extraction group. The changes observed for the early extraction group (0.6 mm/yr), have also been previously reported.[22] Importantly, group differences in intercanine width might be related to the timing of premolar extraction, or to the retraction of the maxillary canines; there were no occlusal interferences present on the canines.

Most orthodontists accept that mandibular plane angle will decrease with extraction therapy,[25] resulting in a deepening of the bite. The effect is usually explained by mesial movement of the molars into the extraction sites, which allows the mandibular plane to rotate anteriorly. With the exception of an openbite malocclusion, this is usually an undesirable sequela. This study showed no decrease of the mandibular plane angle, which might be partially attributed to the minimal absolute movements of the molars into the extraction site. Any mesial movement which did occur was accompanied by vertical eruption of the molar to prevent angular change in the mandibular plane. Nevertheless, greater mandibular plane rotation may occur when appliance therapy immediately follows extraction to close the extraction spaces.

Table 6
Paired t-tests evaluating z-score differences (post-extraction minus pre-extraction)

Variables showing no group differences

Variable	Groups	Z-score Difference	SD	t	DF	Prob
$I1_e$-Me	1&2	0.43	0.47	-6.64	51	<0.001
$M1_c$-MP	1&2	2.29	0.66	-24.83	51	<0.001
S-N/MP	1&2	-0.12	0.47	1.86	51	0.069

Variables showing group differences

Variable	Group	Z-score Difference	SD	t	DF	Prob
I1/MP	1	-0.62	0.81	4.36	31	<0.001
	2	-0.90	0.56	7.02	18	<0.001
AD	1	-2.84	0.80	20.00	31	<0.001
	2	-1.60	0.90	7.75	18	<0.001
ICW	1	1.11	1.49	-4.21	31	<0.001
	2	0.80	0.77	-4.52	18	<0.001
IMW	1	-0.93	0.68	7.77	31	<0.001
	2	-0.05	0.24	0.85	18	0.405

Summary

Physiologic drift of the dentition - "driftodontics" - following extraction of four first premolars can produce desirable changes. The extraction sites will begin to close and incisor crowding spontaneously corrects itself. Late extraction produces changes that are mainly due to distal movements of the mandibular canines and incisors; the mandibular molars remain relatively more stable. Rates of incisal change for the early extraction group are more limited; molar changes are similar to those seen with late extraction. Future studies are clearly required using a more homogeneous sample to analyze the temporal variation in rates of change and to evaluate the influence of maxillary arch changes during the period of drift.

Author Address

P.H. Buschang
Baylor College of Dentistry
3302 Gaston Avenue
Dallas, Texas 75246

S.G. Papandreas is in private practice in Columbus, Ohio.

P.H. Buschang is Associate Professor of Orthodontics at Baylor College of Dentistry, Dallas, Texas.

R.G. Alexander is Clinical Professor at Baylor College of Dentistry and is in private practice in Arlington, Texas.

D.B. Kennedy is in private practice in Richmond, British Columbia.

I. Koyama is in private practice in Osaka, Japan.

References

1. Tweed C. Clinical Orthodontics. St. Louis: C.V. Mosby Co, 1966.
2. Alexander RG. The Alexander Discipline. Glendora, CA: Ormco Corporation, 1986.
3. Creekmore, TD. Teeth Want to be Straight. J Clin Orthod 1982;82:745-764.
4. Bourdet M. Researches et Observations Sur toutes les parties de l'art du Dentiste, Paris, 1957.
5. Cookson A. Space closure following loss of lower first premolars. Dent Prac 1971;21:411-16.
6. Dale JG. Chapter 5 In: Graber TJ, Swain BF, editors. Orthodontics: Current Principles and Techniques, St. Louis: C.V. Mosby Co, 1985.
7. Wagers LE. Preorthodontic guidance and the corrective mixed-dentition concept. Am J Orthod 1976;69:1-12.
8. Stephens CD. The rate of spontaneous closure at the site of extracted mandibular first premolars. Brit J Orthod 1983;10:93-97.
9. Campbell-Wilson M. Preliminary investigation into the movement of the lower labial segment following loss of the first premolars. Brit J Orthod 1975;2:25-28.
10. Björk O and V Skieller. Facial development and tooth eruption; an implant study at the age of puberty. Am J Orthod 1972;62:339-83.
11. Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. Am J Orthod 1975;68:555-63.
12. Dahlberg G. Statistical Methods for Medical and Biological Students. London: George Allen and Unwin, Ltd, 1940.
13. Riolo ML, Moyers RE, and McNamara, Jr.JA. An Atlas of Craniofacial Growth. Ann Arbor: The University of Michigan, 1974.
14. Moyers RE, Van Der Linden PGM Frans, and Riolo ML. Standards of Human Occlusal Development. Ann Arbor: The University of Michigan, 1976.
15. Sjolien T and Zachrisson B. Periodontal bone support and tooth length in orthodontically treated and untreated persons. Am J Orthod 1973;64:28-37.
16. Kennedy DB, Joondeph DR, Osraberg SK and Little RM. The effect of extraction and orthodontic treatment on dentoalveolar support. Am J Orthod 1983;83:183-90.
17. Sharp W, Reed B, Subtelny JD, and Polson A. Orthodontic relapse, apical root resorption, and crestal alveolar bone levels. Am J Orthod 1987;91:252-58.
18. Joondeph R, and Reidel A. Second premolar serial extraction. Am J Orthod 1976;69:169-84.
19. Weber AD. A longitudinal analysis of premolar enucleation. Am J Orthod 1969;56:394-402.
20. Robertson NAE, Cavina R, and Moss JP. The effect of the extraction of lower first premolars on the migration of teeth in the human dental arch. J Dent Res 1979;58:1252-1256.
21. Glauser R. An evaluation of serial extraction among Navajo Indian Children. Am J Orthod 1973;63:622-32.
22. Kinne JH. Untreated firt premolar serial extraction: Long term observation.. M.S.D. thesis, Univ. of Washington, 1975.
23. Norman F. Serial extraction. Angle Orthod 1965:35:149-57.
24. Berg R and Gebauer V. Spontaneous changes in the mandibular arch following first premolar extractions. Eur J Orthod 1982;4:93-98.
25. Graber TJ, Swain BF. Orthodontics: Current Principles and Techniques. St. Louis: C.V. Mosby Co, 1985.