First Premolar or Second Premolar Extractions: Formula or Clinical Judgment?

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Orthodontists daily make decisions regarding the plans of treatment to be followed for their patients after carefully and exhaustingly conducting cephalometric and roentgenological studies in combination with clinical evaluation and model and photographic analyses. In spite of the wealth of material available for planning treatment, ultimately decisions are related to an entity which we call "clinical judgment." This judgment is derived from experience with similar cases, extensive training, and a rather subjective integration of the patient's orthodontic situation with the aforementioned diagnostic evidence.

While this system of diagnosis has been most effective and quite successful for many patients, it is also recognized that, in the interest of objectivity and uniformity of treatment, a more concrete and consistent expression of the orthodontist's clinical judgment would be desirable. When I began thinking about the reasons why sometimes second premolars are extracted rather than first premolars, I also began to quiz other orthodontists as to what were the most important factors in their decisions to extract second rather than first premolars when they did so. There did not seem to be any diagnostic criterion considered *most* important. Often my question was answered with generalized statements such as, "the nose and chin point were prominent," "the molars had drifted mesially," "there is only a slight arch length discrepancy," "there is an openbite," etc. No answer was really definitive. I felt that there must be a more scientific approach to the selection of first rather than second premolars, but doubted whether there was a formula for clinical experience.

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That there is difficulty in interpretation of a cephalometric analysis is evident. A cephalometric evaluation has no reference to anterior component of force, development of the tongue or its position in the mouth and the effect the tongue will have on the teeth, development of the airway and what may happen with the involution of the adenoid and tonsillar tissue. Allergies and resultant postnasal drainage and mouthbreathing are not evident on headplates. Will intermaxillary anchorage be utilized in conjunction with high or low-pull headgear, and what effect will extraoral anchorage have on the basal bone? These and many other variable entities must be evaluated by the orthodontist who exercises "clinical judgment."

REVIEW OF THE LITERATURE

In 1947 Carey[1] stated that when the arch-tooth discrepancy is only a few millimeters, it is generally good practice to remove the second premolars. He found that treatment without extraction in most cases measuring deficiency of bone in excess of two and one half millimeters is *possible* provided the operator is willing to accept a compromise result. Reference to this material, printed over thirty years ago is worthwhile reading.

Another early reference to second premolar extraction was by Nance[2] in 1949. He spoke of removing second rather than first premolars in an effort to keep the incisors over basal bone.

In 1955 Dewel[3] treated and reported a borderline extraction case in which extraction of second premolars was utilized. He still found relapse of rotations, but felt that this was less severe than would have occurred with extraction of first premolars or no extractions.

Analyzing second premolar extraction

procedures in 1964, Schoppe[4] wrote that since there is variation in the type and severity of orthodontic cases, there must be a variety of treatment plans and appliance techniques. He concluded that when arch-length discrepancy is seven and a half millimeters or less, and there was no need for incisor retraction, it may be advisable to remove second rather than first premolars, if extractions are to be performed. This paper and others published about that time began to consider cephalometric landmarks in determining the selection of teeth for removal. Previously, procedures used in diagnosis were primarily concerned with photographs for profile evaluation and model analysis to determine arch-length discrepancy and other dental variations.

In 1964 Ricketts[5] indicated the orthodontist should try to place the lower incisors within one standard deviation of the APo plane as located at the end of treatment and possibly later. He attempts to treat toward a mean of the lower incisor to the APo plane of +.05 millimeters feeling this is a sensible guide in the light of contemporary esthetics and functional objectives.

Continuing review of the literature now begins to show more interest in the soft-tissue evaluation in *combination* with the cephalometric analysis, so that a somewhat more sophisticated approach to the selection of extraction sites can be utilized. Again this is primarily due to the work of Ricketts[6] in 1968 when he stated, "A correlation of morphology and function is implicit in most conditions of lip relations — what looks good usually works well." He pointed out that lip prominence seems to be an undesirable trait and an unacceptable situation, particularly in adults, but that lip fullness is a characteristic of the young. He developed the "E" line and as an objective for the pubertal age (finished at 12 to 14 years), his mean for the lower lip is 2 mm±3 as an orthodontic working range. Ricketts also feels, "in the normal white person at maturity, the lips are contained within a line from the nose to the chin, the outlines of the lips are smooth and contoured, the upper lip is slightly posterior to the lower lip when related to that line, and the mouth can be closed with no strain."

In 1971, in a discussion on soft-tissue profile, Edgerton[7] studied nose and chin growth, uprighting of the dentures with growth, and changes in the lips with treatment. He concluded that there was so much variation in soft tissue between one patient and another, even in similar malocclusions, that he recommends giving more attention to growth and change of tissue on an individual basis rather than attempting to classify soft-tissue standards.

In 1973, Logan[8] reported after studying eighteen consecutively treated Class I and eighteen consecutively treated Class II cases, that mandibular molars can be moved farther mesially in Class II cases with extraction of second premolars. He also stated that such extraction facilitates closure of an open bite by reducing posterior (vertical) dimension. He reported less retraction of both mandibular and maxillary incisors with the resultant less need for Class II elastics, less anterior torque problems, and less overall extraoral traction time.

In 1974 De Castro[9] stated that when extractions are utilized at the junction of the anterior segment and the two posterior segments, the integrity of the dentition as a functional machine is disturbed more than when there is extraction in a segmental unit. When first premolars are removed the transitions are *abrupt* in the anterior segment, but when second premolars are removed, the transitions are *gradual.* He also wrote that when the arch-tooth discrepancy is five millimeters or less in a patient with a good profile, extraction of second premolars is indicated. He believes most orthodontists agree that, in the average extraction case, the profile does not need changing and referred to better function with a canine-first premolar contact relationship than with a canine-second premolar contact relationship. This

canine-first premolar combination helps to protect the canines in function, and he felt that the poor contact relationship between the first molar and first premolar could be overcome with mesiolingual rotation of the first premolar.

Brandt and Saferstein[10] in 1975 stressed that extractions affect facial esthetics. They pointed out that noses and chin buttons continue to grow after treatment (as had been noted by Ricketts and others), and that this must be considered in deciding which teeth must be sacrificed. Their concern in soft tissue and its relationship to incisor position is typical of the current interest in lips and chins and their importance in diagnosis.

In a very detailed article Joondeph and Riedel[11] in 1976 stated that the drift pattern in cases where second premolars are absent is more favorable than with first premolar extractions, when the canines and second premolars tip into the extraction spaces. They also feel early removal of second premolars should be considered in the absence of dental and facial protrusion, reducing the possibility of flattening the profile. When lingual movement of the incisors is indicated they advise extraction of first premolars.

Williams and Hosila[12] wrote in 1976 that whether diagnosis is based on the APo line, the Steiner analysis, or the Tweed triangle, the position of the lower incisor is of prime importance, and each clinician has a concept of where he wants to put the teeth for maximum stability, esthetics, and function. The amount of incisor retraction is determined by varying the extraction site. This should be considered in the diagnosis so the desired treatment goal for the final position of the incisors can be achieved.

Also in 1976 Posen,[13] in his evaluation of the tonicity of the perioral musculature, advises extraction of second premolars when extraction is necessary in patients with hypertonic lip muscles. His work and interest in the pommeter, an instrument he designed to measure lip activity, is also typical of the swing toward soft-tissue evaluation.

Material and Methods

Part I

Records of forty-three patients were studied to determine what differences existed which influenced the decision to remove first or second premolars. Their average age was 12 years, the range being 8.3 to 22.8 years. There were twenty-three girls and twenty boys, selected from patients seen in our office over a two-year period and limited to those patients having either all four first premolars or all four second premolars removed.

The following cephalometric readings determined extraction sites: mandibular plane, interincisal angle, lower incisor to mandibular plane, and lower incisor to APo (millimeters and degrees). Also included was the Class I or Class II classification, and the tooth-arch size discrepancy as described by Carey. The 3.4 millimeter "inevitable drift of the first molars" was not used, however. Tables I and II show the means and standard deviations of the sample.

These two extraction groups were compared in terms of each of these variables through the use of the Student's "t" test. A probability level of .05 was selected; if the level was over .05, we assumed no significant difference between the groups.

Results

Part I

Tabulation revealed that there was no significant difference ($p=.05$) between the first premolar extraction group and the second premolar extraction group in terms of the aforementioned cephalometric and other indices; nor was there significant difference between the Class I and Class II patients when each extraction group was considered separately; nor was there significant difference between the first premolar extraction group and the second premolar extraction group when the Class I

TABLE I

PATIENTS WITH FIRST PREMOLAR EXTRACTIONS

Patients	Mand. Plane	Inter-incisal Angle	$\overline{1}$ to Mand. Plane	$\overline{1}$ to APo mm.	$\overline{1}$ to APo degree	Tooth-arch Discrepancy (mm)
Class I						
Mean	29.2	129.5	+1.4	+1.4	23.9	4.9
S.D.	3.99	9.25	6.43	1.24	7.06	2.29
Class II						
Mean	28.6	132	+1.6	+0.7	19.2	5.6
S.D.	3.20	10.18	5.80	2.37	8.64	2.91

TABLE II

PATIENTS WITH SECOND PREMOLAR EXTRACTIONS

Patients	Mand. Plane	Inter-incisal Angle	$\overline{1}$ to Mand. Plane	$\overline{1}$ to APo mm.	$\overline{1}$ to APo degree	Tooth-arch Discrepancy (mm)
Class I						
Mean	26.8	132.1	+0.3	+0.6	21.6	5.1
S.D.	5.09	10.07	7.02	2.83	7.91	3.02
Class II						
Mean	23.1	126.9	7.8	1.6	26.5	3.1
S.D.	4.38	13.59	8.89	2.32	7.65	1.65

and Class II patients were considered separately.

It should be noted that the previous statements apply only to those parameters which were measured in the present sample. They were however, those which I felt were most significant to me in determining the position of the lower incisors in the profile which was our goal in a given case.

Discussion

Since within the limitations of this portion of our study, there was no variable found upon which a decision for a particular form of treatment plan could be based, we might infer that treatment plans were developed on the basis of nonobjective variables. This assumption would seem to be fallacious and the results must be much more carefully examined. Only six variables were examined in this study. Needless to say, there is a great deal more to orthodontic diagnosis and treatment than the measurement of six objective indices. There is a subjective evaluation, and a host of other variables which were not used. A few of these are considered in subsequent paragraphs.

Material and Methods

Part II

It was decided to try to measure the impression we receive when looking at the profile of the patient, specifically the position of the lips in relation to the nose and chin point. It would seem that removal of teeth toward the anterior part of the dental arches would have a recessional effect on the lips, if the tooth-arch discrepancy was not great enough to dissipate the space gained by the extractions. Conversely, removal of teeth farther back in the arches should have less effect on the lips under the same discrepancy situation.

By utilizing the Frankfort plane on the

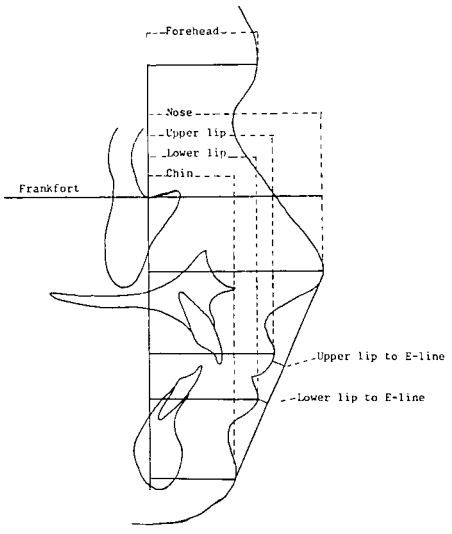

Fig. 1

initial cephalometric tracing, we measured the distance in millimeters from a perpendicular to Frankfort drawn through orbitale to the following points (Fig.1): the most anterior part of the forehead, the tip of the nose, the upper lip, the lower lip, and the soft-tissue chin. Orbitale was selected as a bony point that was not too far removed from the soft-tissue points used and was not affected greatly by growth and not at all by appliance therapy.

To have an appreciation of the prominence of the nose and chin in relation to the lips, the distances from orbitale to nose tip and chin were combined, as were the distances from orbitale to upper and lower lips. These measurements were tabulated as NCLL.

In addition, Ricketts E-line was used to measure the millimetric distance from the E-line to the upper lip and lower lip on a perpendicular to the E-line. The lips were measured individually and also combined for an average lip distance to the E-line.

Results and Discussion

Part II

Table III shows the means and standard deviations of the measurements for the subjects separated by groups. The

TABLE III

SOFT TISSUE EVALUATION
(in millimeters)

	From a Perpendicular to Frankfort (at Orbitale) to					Nose + Chin to Up. + Low. Lip (NCLL)	Lips to E-line*		
	Fore head	Nose Tip	Upper Lip	Lower Lip	Chin*		Upper Lip	Lower Lip	Both Lips
1st Premolar									
Mean	26	42.7	30	28.5	14.9	+3.55	−.15	+1.35	+.55
Class I S.D.	3.88	4.05	4.82	4.82	5.61	4.88	2.42	1.72	2.08
1st Premolar									
Mean	26.8	43	31	27.3	13.6	+2.45	−.15	+1.85	+.85
Class II	5.23	3.11	3.78	4.23	5.24	5.41	1.80	2.35	2.16
2nd Premolar									
Mean	26.9	45	32.6	30	22.3	−2.61	−3.44	−1.33	−2.39
Class I S.D.	3.15	2.30	2.61	3.50	5.73	3.99	1.90	2.16	2.00
2nd Premolar									
Mean	26.3	46.3	33	30	22.1	−3.54	−3.54	−1.29	−2.41
Class II S.D.	2.41	2.78	4.21	4.26	5.62	3.93	2.01	1.97	1.92

*Group means were significantly different at the .05 probability level of significance.

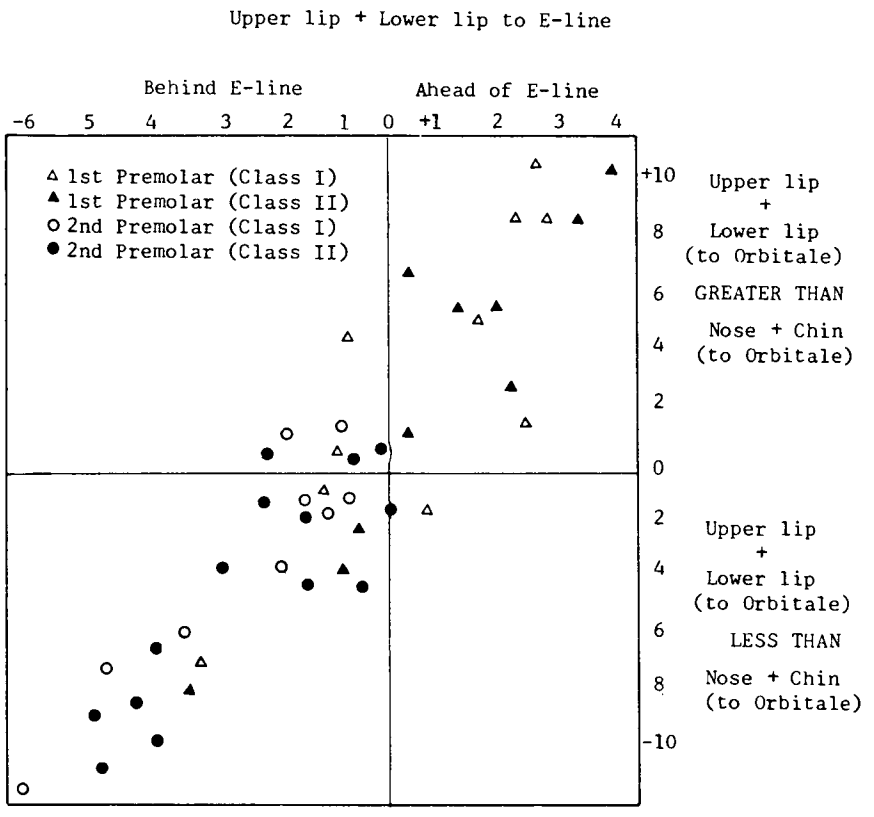

Fig. 2

forehead measurements were practically the same for both first premolar Class I or Class II groups and the second premolar Class I or II groups.

The nose tip mean measurement and both lip mean measurements also proved to be quite similar in all four groups although the nose tip and the lower lip were slightly larger for the second premolar groups.

The chin mean measurements for the second premolar patients were higher than the first premolar mean measurements. When the NCLL measurements and means were compared, a pattern of smaller nose + chin in relation to lips for first premolar extraction patients than for second premolar extraction patients began to develop. The difference here is not really the nose, but the chin.

In studying the lips to E-line means we discovered that the means for the upper lip for all first premolar cases were almost identical, as were the means for all second premolar cases. This was also true for the lower lip. The means for the upper and lower lips combined, however, were much larger for first premolar cases than for second premolar cases.

A scattergram was constructed (Fig. 2) utilizing the NCLL differences and the lip to E-line differences to evaluate the soft tissue. The symbols in the upper right quadrant are cases with lips ahead of the E-line and more prominent than the combined nose and chin. Those in the lower left quadrant are cases with lips behind the E-line and less prominent than the combined nose and chin. In clinical practice these would be the easier cases to diag-

TABLE IV

GROUP MEANS AND STANDARD DEVIATIONS

Variable	Four Mean	Four Std. Dev.	Five Mean	Five Std. Dev.	F test
Forehead	27.2	4.50	26.6	2.66	0.31
Nose tip	43.0	3.52	45.8	2.63	9.03*
Upper lip	32.0	3.82	32.8	3.60	0.50
Lower lip	27.9	4.46	29.9	3.90	2.50
Chin	13.8	5.29	20.1	5.54	14.58*
E line to U. & L. lips	0.73	2.07	−2.4	1.90	26.65*
Mandibular plane	28.9	3.59	24.9	4.73	10.93*
Interincisal angle	130.8	9.71	129.5	11.83	0.29
⌐1:Mandibular plane	1.5	6.12	4.0	7.95	2.08
⌐1:APo (mm)	1.1	1.80	1.1	2.57	0.04
⌐1:APo (degrees)	21.5	7.85	24.1	7.78	1.52
Tooth-arch discrepancy	5.2	2.26	4.1	2.34	3.26
Nose tip + Chin	56.8	7.31	66.0	7.12	
Lower lip + Upper lip	59.9	7.83	62.7	7.41	
			Group Four vs. Group Five		14.05
Nose tip + Chin (Four) vs. Nose tip + Chin (Five)					17.27
Lower lip + Upper lip (Four) vs. Lower lip + Upper lip (Five)					1.46

*Indicates that group means were significantly different at the .05 level of significance.

nose, but those near the center of the scattergram require a fine sense of "clinical judgment."

Material and Methods

Part III

A discriminant analysis of the cephalometric and soft-tissue measurements and tooth-arch size discrepancy was done to determine which of the measurements would best discriminate (or classify) among the four groups of patients: Four I (first premolar extraction Class I), Four II (first premolar extraction, Class II), Five I (second premolar extraction, Class I), and Five II (second premolar extraction, Class II). The analysis using the four groups showed very *poor* discrimination among all groups.

A multivariate analysis of variance was done next to see if groups Four I and Four II differed on any of the measurements. The F test was used rather than the "t" test because of the number of variables used. When F approaches 1 there is almost no difference between the groups evaluated. The result was not significant ($F=1.21$ with 14 and 26 degrees of freedom. F had to be 2.10 or above to be significant). A similar analysis was done to see if groups Five I and Five II differed on any of the measurements. The test in this case was also nonsignificant ($F=1.09$). Since these pairs of groups were so homogeneous, they were combined so that Group Four consisted of Four I and Four II, and Group Five consisted of Five I and Five II.

A second discriminant analysis was done using these two groups of patients: Four (first premolar extraction), and Five (second premolar extraction). The means and standard deviations of the measurements for these groups are listed in Table IV.

Results

Part III

Two variables were found important in discriminating between the two groups of patients: (1) the *average* distance from the E-line to the upper and lower lips, and (2) the angle of the lower left central to the APo line. These two measurements taken together classified correctly 16 of the 20 first premolar extraction patients and 19 of the 23 second premolar patients. It should be noted that using the average distance from E-line to the upper and lower lips by itself classified 16 of 20 first premolar extraction patients correctly and 17 of the 23 second premolar extraction patients correctly. The addition of the second variable (angle from the lower left central to the APo-line) added little to the discrimination except in helping to identify second premolar extraction patients.

Some measurements were significantly different between the groups, but were not brought into the discriminant function due to their close relationship to the variables already in the discriminant function. These were: length to nose tip, length to chin and mandibular plane. These measurements, although not important in the discriminant analysis after the entrance of the two original variables discussed above, might be important in future studies.

If one uses the average distance from the E-line to the upper and lower lips by itself to classify patients he would classify a patient as first premolar extraction if the patient's average distance was greater than -.84 mm (average of .73 and -2.4, Table IV), otherwise he would be classified as a second premolar extraction case. Using this method one could expect to correctly classify about 80% of the first premolar and 73% of the second premolar extraction patients based on the results of this study.

The addition of the second variable (angle of the lower left central to APo) increased our ability to classify second premolar extraction cases correctly. If we let x=average distance from E-line to the upper and lower lips and y=the angle from the mandibular left central to the APo line, then we would classify a patient as first premolar extractions if $y-8.13x<29.87$, otherwise classify the patient as a second premolar extraction case. The 8.13 came from the discriminant analysis, its function was to clear the fraction in the computer analysis. Using this method we could expect to classify correctly 80% of the first premolar extraction patients and 83% of the second premolar extraction patients.

An additional analysis was done to see if the groups differed on nose tip + chin and lower lip + upper lip. Table IV also contains the means and standard deviations for the groups. A multivariate analysis was done to see if the groups differed on these two variables jointly. The result was that the groups differed significantly ($F=14.05$). Since the groups differed significantly, a second test was done to see which of the variables caused rejection. The group means for nose tip + chin were significantly different ($F=17.27$), while the difference between the groups for lower lip + upper lip was not ($F=1.46$).

Conclusion

By utilizing standard diagnostic procedures in our office, decisions were made on a number of extraction cases, selecting four first premolars or four second premolars as the preferable teeth to remove. An effort was made to determine whether there were some objective variables which were significantly different for first premolar extraction cases and second premolar extraction cases.

It was found that, for the cephalometric indices used in this study and the tooth-arch size discrepancy, there were no parameters which were significantly different.

When soft-tissue measurements were included however, and a discriminant computer analysis completed, it was discovered that the nose tip, the chin, the

mandibular plane and the relation of the lips to the E-line were statistically significant in determining whether the case was a first or second premolar extraction case.

The combination of lips to E-line and lower left central to APo (angle only) was helpful in classifying second premolar cases.

It must be emphasized that these parameters were for the results of this sample only. Further, this entire study assumed that the diagnostician has already decided that the case being evaluated is indeed a case requiring sacrifice of dental units in both maxillary and mandibular arches, and that the extraction site should be in the premolar area.

In applying our formulae to a specific patient they may serve as an aid to our diagnosis. The additional utilization of the nose length, chin length and mandibular plane angle all used singly, help to identify where the patient varies from the above standard formula, when the formula does not seem clinically applicable.

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