Original Article

Occlusal Development in Children of African American Descent

Types of Terminal Plane Relationships in the Primary Dentition

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ABSTRACT

Objective: To compare the types and depths of the terminal plane relationships (mesial step, distal step, and flush) in the primary dentitions of African American (AA) and European (E) children.

Materials and Methods: A convenience sample of 189 African American children (103 males and 86 females) was compared to a historical sample of 61 European children (39 males and 22 females, age range 2.1 to 5.2 years, mean age of 4.1 years). Plaster dental casts were analyzed for both samples. Terminal plane depth (TPD) was defined as the anteroposterior distance (APD) between the distal surfaces of the maxillary and mandibular second primary molars of dental casts registered in centric occlusion. Sample differences were evaluated using a 2-sample independent group *t*-test.

Results: Eighty-nine percent of African American children and 63% of European children exhibited a mesial step terminal plane. The average APD of the mesial step in African American children was 1.29 mm compared to 1.13 mm in European children, but this was not statistically significant ($P = .18$). The samples differed significantly ($P = .001$) in the average APD distal step relationship (AA, 1.08 mm vs E, 2.26 mm). The prevalence of distal step relationships was lower in African American children (5%) compared to European children (16%). African American children had a lower prevalence of flush terminal plane (6%) compared to European children (21%).

Conclusions: In African American children as in European children, a mesial step, rather than a flush terminal plane, is the norm for the completed primary dentition.

KEY WORDS: Primary dentition; African American; Terminal plane; Depth; Classification; Occlusion

INTRODUCTION

As previously reported,[1] epidemiological studies[2–5] dealing with the sagittal arrangement of the jaws (dental arches) suggest certain racial (African American vs European) differences in the distribution of the occlusal relationships in human dentitions, especially the permanent dentition.

Theories regarding the mechanisms of occlusal development in the permanent dentition begin at the terminal plane of the completed primary dentition. Along with greater emphasis on prevention and early treatment, increased focus has been directed at classification of occlusal development in the primary dentition (Table 1). Few studies of the primary dentition and occlusal development of African American children have been undertaken, and none have quantified (metrically) the types of terminal plane relationships in this population.

Classification of occlusion in the permanent dentition describes the sagittal relationship of the buccal surfaces of the maxillary and mandibular first molars.[6] In the primary dentition, classification is routinely based on the anteroposterior distance-terminal plane difference (APD-TPD, Figure 1) between the distal surfaces of the opposing primary maxillary and mandibular second molars. Investigations have focused on the types of terminal plane relationships in the primary dentition in an effort to forecast occlusal relationships in the permanent dentition.[7–9]

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TABLE 1. An Analysis of Investigations Related to Terminal Plane Classification of Primary Dentitions

Source Investigator(s)	Sample			Tooth Surfaces Examined[a]	Type Data Recorded[b]	Class Distance, mm			Class Frequency, %		
	Lineage	Age, y	n			Mesial Step	Flush TP[c]	Distal Step	Mesial Step	Flush TP[c]	Distal Step
Baume[13]	European	3–4.5	30	Distal	Visual	—	—	—	14	76	10
Clinch[14]	European	3–8	61	Distal	Metric	>2	±2	>2	6	63[e]	31
Bonnar[15]	European	2.7–3.5	8	Distal	Metric	—	—	—	63	—	—
Carlson & Meredith[7]	European	3.5–5	109	Distal	Metric	>0	±0	>0	87	⟵ 13 ⟶[f]	
Arya et al[8]	European	4.5–14	118	Distal	Metric	>0.5	±0.5	>0.5	49	37	14
Infante[5]	European	2–5	680	Buccal	Visual	—	—	—	1	80	19
Infante[5]	African	2–5	141	Buccal	Visual	—	—	—	7	89	4
Infante[5]	Indian	2–5	75	Buccal	Visual	—	—	—	8	89	3
Bishara et al[9]	European	4.9	121	Distal	Metric	≥1	±0.9	≥1	61	29	10
Jones et al[16]	African	3–4	493	Distal	Visual	—	—	—	90	8	2
Kabue et al[17]	African	3–6	221	Distal	Visual	—	—	—	43	53	1
Farsi & Salama[18]	Asian	3–5	520	Distal	Visual	—	—	—	12	80	8
Trottman & Elsbach[19]	European	2–5	139	Buccal	Visual	—	—	—	8	78	14
Trottman & Elsbach[19]	African	2–5	99	Buccal	Visual	—	—	—	17	76	7
Howard[d]	African	3.6–6.8	189	Distal	Metric	>0.1	±0.1	>0.1	89	6	5
Cinch's[14] appendix	European	2.1–5.2	61	Distal	Metric	>0.1	±0.1	>0.1	63	21	16

[a] Distal, primary 2nd molars; buccal, Angle's method of classification using the primary 2nd molars.
[b] Visual, inspection; metric, measured in mm.
[c] TP, terminal plane.
[d] Howard University location of this study.
[e] Computed by substraction.
[f] Flush and distal combined.

Zigmond,[10] and later Chapman,[11] observed that in the occluded primary dentition the distal surfaces of the maxillary and mandibular second molars were approximately "coincidental" (flush terminal plane) and that some adjustment mechanism must occur if the accessional permanent first molars are to occlude correctly (Class I) upon eruption. Friel[12] suggests that the "coincidental" nature of the opposing primary maxillary and mandibular second molars is due to the differential mesiodistal crown width of the teeth, the mandibular second molar being wider than the maxillary second molar causing a flush terminal plane.

Anderson[1] observed different posterior sagittal (maxillary over mandibular) primary tooth size ratios between African American (0.96) and European (0.94) children and hypothesized possible population differences in terminal plane depth (TPD) relationships.

Other interracial and intraracial investigations[7–9,13–19] of terminal plane relationships recorded wide variations in the frequency of the various classifications (mesial step, distal step, and flush) as summarized in Table 1. This is especially true for the flush terminal plane (range 29% to 80%), the type most often cited as the norm for the primary dentition.[20,21]

The aim of this investigation was to quantify and compare the types and depths of terminal plane relationships observed on casts of the completed primary dentitions of African American and European children employing the same methodology.

MATERIALS AND METHODS

Human Sample Size, Source, and Selection

A convenience sample of 189 children of African American descent (103 males and 86 females) participated in the study. The children ranged in age from 3.6 to 6.8 years, with a sample mean age of 4.9 years. They were a randomly selected group of children who attended a mid-city (Washington, DC) kindergarten school. A sample of 61 European children (39 males and 22 females), spanning an age range of 2.1 to 5.2 years with a mean age of 4.1 years, was previously reported by Clinch.[14] The sample data were constructed from the appendix of Clinch's measurements. Both population samples were restricted to the completed primary dentition. Two possible interpopulation sample biases are noted: (a) a small European female sample size and (b) an older mean age of the African American sample (8 months).

Plaster Dental Casts, Occlusal Registration, Measuring Technique, and Instrument Error

Plaster dental casts (registered in centric occlusion) made from alginate impressions were used to measure TPD relationships in both populations. In this study, when in doubt about the articulation of centric occlusion, the occluded dental casts were matched with intraoral photographs of the recorded centric occlusion taken prior to the impression. The digital caliper (Sentry Dental, Farmingdale, NY) used to measure APD read to the nearest 0.01 mm. It had a calibrated instrument error of ±0.03 mm for measurements ranging from 0 to 200 mm. The measuring technique described in Figure 1 was employed to overcome the difficulty of approximating and projecting the distal reference point (distobuccal contact) of the primary maxillary second molar onto the mandibular dental cast using a plumb line method as performed by Clinch[14] (Figure 1A). This study, as well as Clinch's,[14] disregarded the fact that the most distal point on the primary maxillary second molar usually lies in the cervical region of the distolingual cusp.

The dental cast selection criteria excluded primary dentitions with (*a*) caries and restorations involving the proximal surfaces of the posterior teeth, (*b*) extracted or missing molars, and (*c*) a patient history of orthodontic treatment.

Method of Measuring and Establishing Boundaries for the Types of Terminal Plane Relationships in the Primary Dentition (Figure 1)

A finely sharpened No. 3 pencil was used to make a mark on the occlusal surface of the primary mandibular second molar at the most mesiobuccal contact point of occlusion with the maxillary second primary molar (Point A, Figure 1B,D). The mark made at point A was not greater than 0.1 mm wide. The distance from Point A on the mandibular second molar to the most distobuccal contact point on the same tooth was measured (measurement A, Figure ID). Next, the distance between the most mesiobucal contact point on the opposing primary maxillary second molar to the most distobuccal contact point on the same tooth was measured (measurement B, Figure 1C).

The terminal planes were classified as follows: (1) flush, when the difference between measurements A and B was no greater than ±0.10 mm, (2) mesial step—measurement B was >0.1 mm longer than measurement A (positive value assigned), and (3) distal step—measurement A was >0.1 mm longer than measurement B (negative value assigned). To arrive at mean values for the ADP-TPD of the various types (classes), each side of the opposing arches was measured, averaged, and distributed according to the above class limits. Clinch's[14] sample of published raw data was treated in the same manner (Table 2).

Differentiating Between Mesial Step Neutrocclusion From Mesiocclusion and Distal Step Neutrocclusion From Distocclusion

When APD reached 3.5 mm or more in a mesial or distal direction, the posterior occlusion was recorded as a partial or complete mesiocclusion (mesiobuccal cusp of the primary maxillary second molar occluded in the distobuccal groove of the primary mandibular second molar) or distocclusion (distobuccal cusp of the primary maxillary second molar occluded in the mesiobuccal groove of the primary mandibular second molar), respectively, as shown in Figure 2C,D. In computing the average APD in a mesial or distal direction, the sum of all measurements was used. The decision to limit the flush terminal plane APD to ±0.1 mm was dictated by Clinch's[14] data.

Statistical Computations

Descriptive statistics were recorded for each dental arch parameter by sex. Sex and population differences were assessed using a 2-sample independent group *t*-test. All statistical data computations were performed using the Winks Software (TexaSoft, Dallas, Tex).

RESULTS

The results summarize TPD measurements of a total of 369 (AA) occluded dental cast sides vs a total of 218 (E) sides (Table 2).

The predominant class of terminal plane relationship observed in both population samples (Table 2) was the mesial step (AA, 89% vs E, 63%). African American male (90%) and female (86%) children showed a greater tendency for the mesial step than European male (63%) and female (62%) children. The average mesial step APD was longer in African American (1.29 mm) children compared to European children (1.13 mm). This trend held true for both sexes (AA males, 1.27 mm vs E males, 1.19 mm; AA females, 1.32 mm vs E females, 1.03 mm [Table 2]). The population sex differences in the mesial step APD was not found to be statistically significant ($P = .18$). The range of the mesial step APD was comparable in both population samples (AA, 0.1 mm to 4.6 mm vs E, 0.2 mm to 4.3 mm).

The distal step was the least frequently observed type of terminal plane relationship in both population samples (AA, 5%; E, 16% [Table 2]). African American males (5%) and females (7%) showed a lower frequency for the distal step than European children (male, 14%; female, 20%). The average distal step APD in African American children was 1.08 mm compared to 2.26 mm in European children. The difference in the average distal step APD was statistically significant ($P = .001$) for the two population samples. The flush terminal plane was observed in only 6% of African American children compared to 21% of European children (Table 2).

The majority of both samples showed a higher frequency of asymmetrical pattern, as opposed to sym-

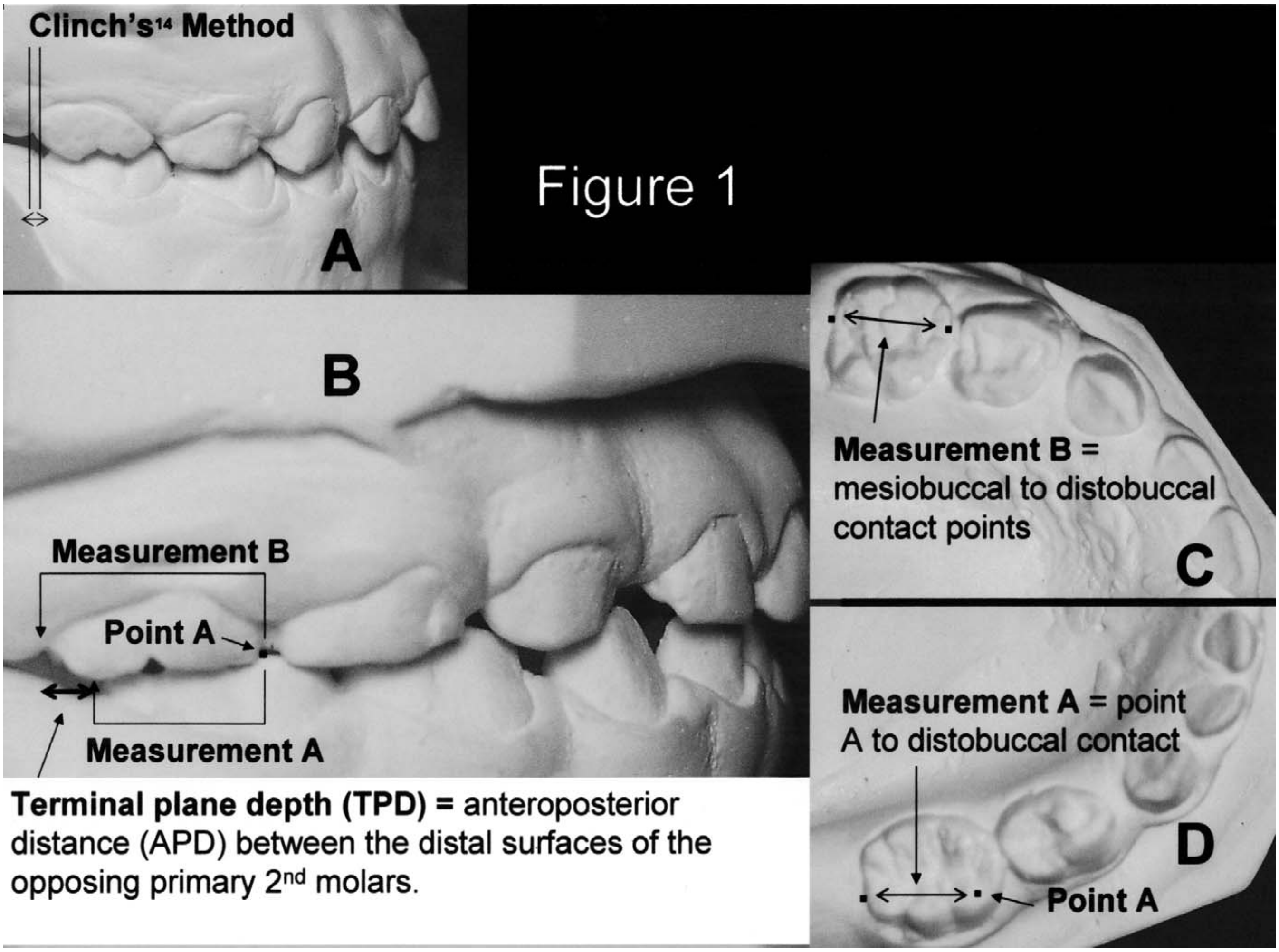

Figure 1. Methods of measuring terminal plane depth (TPD) in the completed primary dentition.

metrical pattern, of terminal plane development (AA, 58% vs E, 61% [Table 3]).

In the African American sample, when the APD of the terminal plane step (in a mesial or distal direction) reached 3.5 mm or more, the posterior interocclusal relationship reflected a partial or complete mesiocclusion or distocclusion, respectively (Figure 2C,D).

DISCUSSION

Theories of occlusal development and arch perimeter space management have been linked with terminal plane types.[20] The lack of agreement permeating the measures of terminal plane types, within a given population, cannot be overlooked in any meaningful discussion pertaining to an investigation of this type (Table 1). Thus, the discussion encompasses (1) rationale for the reported variations in frequency classifications, (2) incongruence in terminal plane classification terminology, and (3) contrasts of this study's findings with the refereed literature.

In analyzing the details of prior investigations, comparative focus must be directed at three areas: (*a*) reference points examined—tooth surfaces (distal surfaces vs buccal surfaces); (*b*) type of data recorded—visual inspection vs measurements; and (*c*) unit distances used to separate the classes—flush, mesial, and distal steps (Table 1). Intra- and inter-lineage investigation differences exist in one or more of the three areas cited above, thus providing a plausible explanation for the reported variations in class frequency percentage (Table 1). For example, variations in class frequency outcome can be expected when area "(*a*)," with regards to reference points, the buccal surface reference points are used since this method does not measure the APD-TPD. The mesiobuccal cusp of the primary maxillary second molar can coincide with the mesiobuccal groove of the primary mandibular second molar, and the class outcome can be either a flush, mesial, or distal step in linear measurement (Figure 2A,B). In area "(*b*)," the type of data recorded (visual

TABLE 2. A Summary of African American and European Convenience Samples of Primary Dentitions and the Associated Statistical Comparisons of Terminal Plane Relationships[a]

	Sample					Mesial Step					Distal Step					Flush	
Source	Sex	n	Sides Meas	Mean Age, y	Range Age, y	Ave, mm	Range, mm	SD	*P*	%	Ave, mm	Range, mm	SD	*P*	%	Ave, mm	%
Clinch[b]	M	39	137	4.0	2.1–5.2	1.19	0.2–4.3	0.71	0.592	63	2.15	0.7–2.7	0.53	0.001	14	0.00	23
Howard[c]	M	103	202	4.8	3.6–6.2	1.27	0.1–4.6	0.82		90	0.95	0.1–2.6	0.93		5	0.04	5
Clinch	F	22	81	4.1	3.0–5.2	1.03	0.2–2.8	0.65	0.147	62	2.37	1.6–3.9	0.73	0.001	20	0.03	18
Howard	F	86	167	4.9	3.7–6.8	1.32	0.1–4.3	0.87		86	1.22	0.1–4.6	1.56		7	0.05	7
Clinch	M+F	61	218	4.1	2.1–5.2	1.13	0.2–4.3	0.69	0.179	63	2.26	0.7–3.9	0.63	0.001	16	±0.02	21
Howard	M+F	189	369	4.9	3.6–6.8	1.29	0.1–4.6	0.84		89	1.08	0.1–4.6	0.90		5	±0.04	6

[a] Meas, measurement; Ave, average.
[b] Clinch's[14] raw data from two sets of dental cast of the completed primary dentition were taken on each patient at about 1-y interval.
[c] Howard University location of study; raw data from one set of dental casts of the completed primary dentition for each patient.

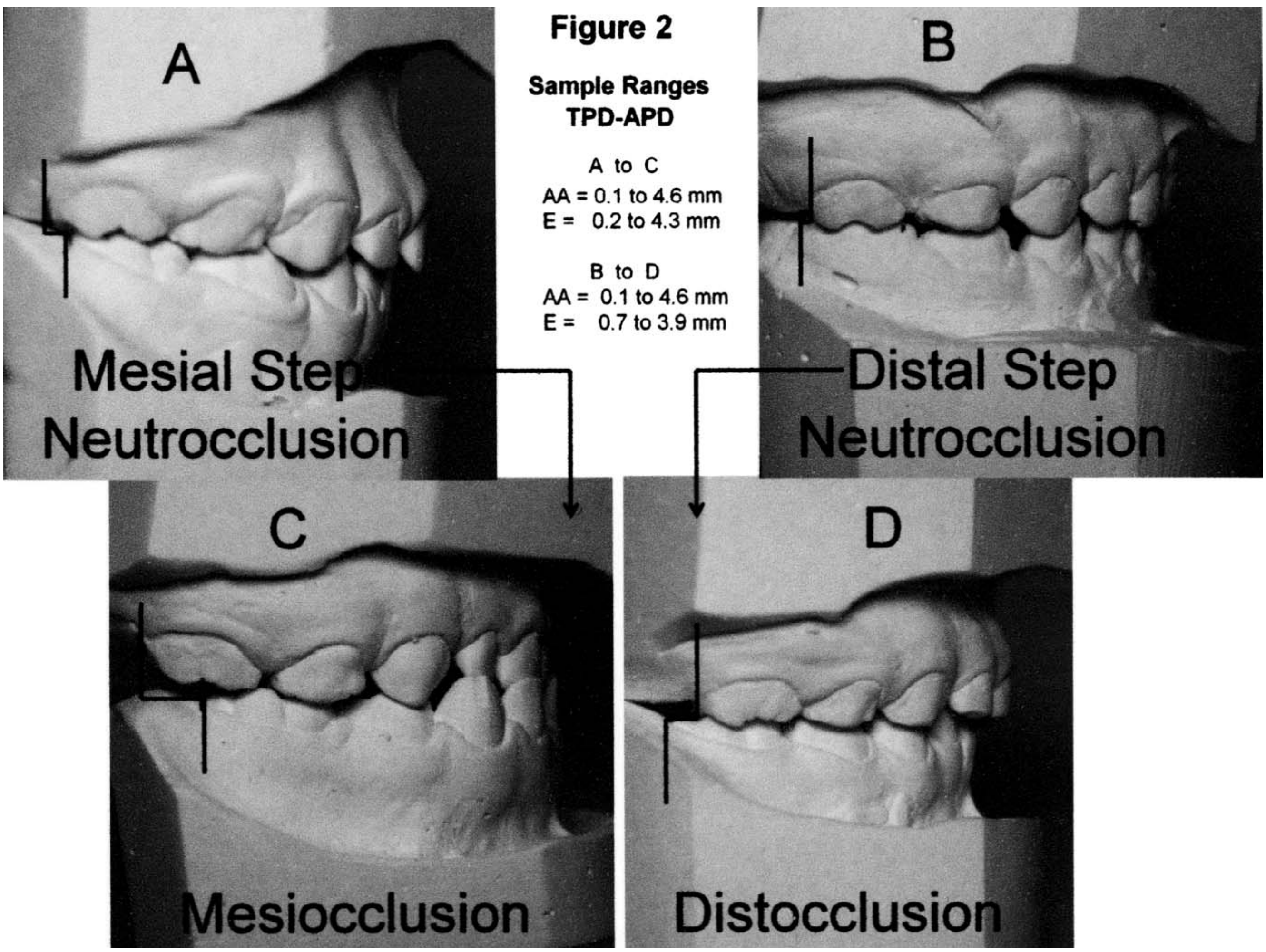

Figure 2. Examples of the types of occlusion based on the anterioposterior distance (depth) of the terminal plane.

vs metric), and in area "(*c*)," the class limit assignment, the points to be made regarding possible variations in results outcome seem apparent, because visual inspection cannot equate with actual linear measurements and unequal class limits result in unequal class frequencies.

Within the scientific literature, incongruence exists in the usage of the terms flush, mesial, and distal step

TABLE 3. Frequency Patterns of Symmetrical and Asymmetrical Terminal Plane Development of the Primary Dentition of African American and European Children[a]

	Sample		Mesial Step		Distal Step		Flush	
Source	Sex	Sides Meas	Sym BL	Asym UL	Sym BL	Asym UL	Sym BL	Asym UL
Cinch[b]		137	38	49	6	13	13	18
Howard[c]	M	202	86	96	2	9	1	8
Clinch	M	81	20	30	5	11	2	13
Howard	F	167	63	81	2	9	1	11
Clinch	F	218	42%	58%	31%	69%	32%	68%
Howard	M+F	369	45%	54%	18%	82%	9%	91%

[a] Meas, measurement; Sym BL, symmetrical bilaterally; Asym UL, asymmetrical unilaterally.
[b] Clinch's raw data.
[c] Howard University location of study.

and the assigned clinical importance of these relationships. By definition, a measurable anteroposterior discrepancy between the distal surfaces of the opposing primary second molars constitutes a step (mesial or distal). For example, Clinch[14] reported her data such that APDs between the distal surfaces of opposing primary second molars within ±2 mm may be classified as a flush terminal plane, thereby requiring some occlusal adjustment between the dental arches to facilitate eruption of the maxillary permanent first molar into optimal occlusion (Class I). A mesial step greater than 2 mm (2.6 mm reported)[14] appears adequate to accommodate eruption of the maxillary permanent first molar into direct optimal occlusion (Class I) without the need for further interdental arch occlusal adjustment. Further analysis of Clinch's[14] data suggests that a distal step greater than 2 mm borders on an APD-TPD adequate to permit distoclusion of the erupting permanent first molars, while an APD-TPD less than 2 mm is classified as a flushed terminal plane. This results in incongruence in the usage of the terms flush, mesial, and distal steps.

Embodied in the flush terminal plane concept, as used by Zsigmondy,[10] Chapman,[11] and Clinch,[14] is an APD-TPD that warrants some interdental arch occlusal adjustment to permit neutrocclusion of the erupting permanent first molars. Clinically, care must be exercised in differentiating a mesial step APD-TPD adequate to permit neutrocclusion of the erupting permanent first molars (Figure 2A) from a mesial step APD-TPD adequate to permit mesiocclusion of the erupting permanent first molars (Figure 2C) and, similarly, distal step neutrocclusion (Figure 2B) from distal step distocclusion (Figure 2D). Thus, implied in the use of the term mesial step is an APD-TPD adequate to permit initial eruption of the permanent first molars into optimal occlusion (Class I) without the need for further interdental arch adjustments.

The flush terminal plane relationship is generally accepted as the norm for the completed primary dentition stage of occlusal development, at least in children of European descent.[20,21] However, the investigations, upon which the general acceptance is based, show wide variations in the reported frequency of the flush terminal plane (range of 29% to 80%) within the European population (Table 1). Prior studies involving the primary dentition of African American children have not measured the APD-TPD in this population.

The results of this study do not support the widely accepted view of a flush terminal plane as the norm for the completed primary dentition of African American or European children. Instead, the results suggested a mesial step of 1.29 mm for African American children and 1.13 mm for European children as the most frequently observed type of terminal plane relationship.

Assuming that Clinch's[14] estimate of 2.6 mm is an adequate APD-TPD to accommodate optimal (Class I) eruption of the first permanent molars, this study's findings suggested a developmental description of the terminal plane relationship in the newly completed primary dentition is a mesial step approximately 50% adequate in African American children and 43% adequate in European children for optimal eruption of the first permanent molars. The mesial step type terminal plane relationship favors a higher incidence of Class I occlusion development than the flush terminal plane, as observed by Arya[8] and Bishara.[9]

With respect to the incidence of mesial step in the respective samples (AA and E children), the findings of this study complement the investigations of Bonner,[15] Carlson,[7] and Bishara[9] (Table 1). Upon careful review of "Clinch's[14] raw data" as reproduced in this study (Tables 1 and 2) and previously examined by Bonner,[15] a mesial step was most frequently observed. The findings also suggested a statistically significant ($P = .001$) population difference in distal step terminal plane relationships. The distal step differences reflected in the frequency data of the respective populations (AA, 5%; E, 16%) imitates the Class II type occlusal relationship ratios reported in the permanent dentitions of these populations.[2–5]

Theoretically, metrically determined APD-TPDs may prove clinically useful in meticulous space management and treatment planning of early mixed dentition occlusal development problems (Figure 1).

CONCLUSIONS

- A mesial step, rather than a flush terminal plane, was the most commonly observed terminal plane relationship in the completed primary dentitions.
- The samples differed significantly in the APD and frequency of the distal step type terminal plane relationship.

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