Intra-arch occlusal indicators of crowding in the permanent dentition

Eduardo Bernabé,[a] César Eduardo del Castillo,[a] and Carlos Flores-Mir[b]
Lima, Peru, and Edmonton, Alberta, Canada

Introduction: The objective of this study was to identify the intra-arch occlusal characteristics that best discriminated 3 groups with different grades of dental arch discrepancies. This cross-sectional analysis was conducted in Lima, Peru, in 2003. **Methods:** Intra-arch measurements were made on 150 sets of dental casts of high school students (aged 12-16; 75 boys, 75 girls). Stepwise multiple discriminant analysis (SMDA) was used to obtain a better understanding of the morphological relationships between tooth and dental-arch variables and their relationship with crowding. **Results:** Mesiodistal tooth sizes and crown proportions of some teeth differed among significantly crowded, mild-to-moderately crowded, and spaced dental arches. Buccolingual tooth sizes were similar in the 3 groups. Of the arch dimensions evaluated, only intermolar arch width and arch length differed between the groups. An SMDA was developed to classify dental-arch discrepancies in the permanent dentition based on several intra-arch occlusal characteristics. The variable with the highest discriminatory capability between groups was arch length. When arch length was taken out of the SMDA, the explanatory capability from the variability on the dental arch discrepancies diminished from 51% to 14%. When the remaining arch dimension variable (intermolar width) was taken out, the explanatory capability diminished more (from 14% to 8%). **Conclusions:** Although other tooth-size and arch dimensions are indicators of crowding, arch length is the most important factor. (Am J Orthod Dentofacial Orthop 2005; 128:220-5)

Crowding occurs when the space required for alignment of the permanent teeth exceeds the space available in the dental arch. This usually results in rotated, ectopic, or impacted teeth.[1,2] Many explanations of the causes of crowding have been proposed, but the condition is still not fully understood. Although evolution, genetics, and environment are possible crowding etiologies reported in the literature, most studies have focused on various clinical characteristics.[1]

One of the most studied areas is the association between tooth size and crowding, but the conclusions of these studies have been contradictory. Although some studies have reported a relationship between mesiodistal (MD) tooth size and crowding,[3-13] others have reported no association.[14-18] It has also been suggested that a determining factor in crowding is not just tooth size, but also tooth shape. Peck and Peck[19,20] were the first to report this association, and their results were later corroborated by some authors[13,21] but contradicted by others.[6,9,16,17] Studies on crowding and its relationship to arch dimensions have also been reported broadly. Many authors[10-12,14,15,22] have demonstrated that arch length, intercanine width, and intermolar width are different in crowded and uncrowded arches.

The impact of many intra-arch occlusal characteristics on crowding can now be evaluated with new powerful multivariate statistical tools. Descriptive multivariate approaches permit us to determine the real contribution on the variability in dental-arch crowding from a pool of variables that can be analyzed as a group or separated. Simultaneous evaluation of several intra-arch occlusal characteristics through a multiple discriminant analysis has been documented only once. Melo et al[22] found that the best occlusal clinical indicators of crowding in the mixed dentition were MD tooth size of the deciduous canine and arch length. To the best of our knowledge, no such statistical approach has been used with permanent dentition data.

Discriminant analysis is a statistical technique that permits us to distinguish between 2 or more predefined groups based on the differentiation or discrimination capability of several contributory variables. Based on the linear equation generated by the discriminant analysis, subjects can be classified according to the results.[23,24] This ability to classify subjects into differ-

[a]Associate professor, Department of Social Dentistry, Universidad Peruana Cayetano Heredia, Lima, Peru.
[b]Postdoctoral fellow, Orthodontic Graduate Program, Department of Dentistry, University of Alberta, Edmonton, Alberta, Canada.
Reprint requests to: Dr Carlos Flores-Mir, Faculty of Medicine and Dentistry, Room 4051A, Dentistry/Pharmacy Centre, University of Alberta, Edmonton, Alberta, Canada T6G 2N8; e-mail, carlosflores@ualberta.ca.
Submitted, February 2004; revised and accepted, April 2004.
0889-5406/$30.00

doi:10.1016/j.ajodo.2004.04.026

ent groups has several uses in prevention, evaluation, screening, and diagnosis.

The objective of this study was to determine which intra-arch occlusal characteristics discriminated best between 3 groups with different amounts of dental arch discrepancies.

MATERIAL AND METHODS

A sample ($\alpha = 95\%$; $\beta = 80\%$) of 150 students, 12 to 16 years old, at a public high school in Lima, Peru, was randomly selected from 321 students who met the selection criteria. This school's population is representative of the Peruvian population in Lima. The subjects had Peruvian ancestors from at least 1 previous generation, with both last names of Hispanic-American origin. No subjects had undergone orthodontic treatment. They had no dental caries, restorations, significant attrition in the proximal surfaces, or anomalies in tooth number, size, or shape.

Crowding was calculated in each arch as the numerical difference between the arch perimeter[25] and the MD tooth size sum. In this study, arches with a space discrepancy of –5.1 mm or more were defined as significantly crowded; arches with a space discrepancy between –0.1 and –5 mm were defined as mild-to-moderately crowded. Proffit[26] set 5 mm as a theoretical cutoff point for required extraction. Similarly, arches with a positive space discrepancy were defined as spaced.

Measurements obtained from the plaster casts included the maximum MD[27] and buccolingual[28] (BL) tooth sizes of all permanent teeth except second and third molars. Once both tooth sizes were obtained, MD/BL ratio was calculated for each tooth as a representation of the crown proportion by applying the formula proposed by Peck and Peck.[19] Intercanine[15] and intermolar[18] arch widths, and arch lengths[18] were also measured.

All measurements were made twice with a sliding caliper (Dentaurum, Pforzheim, Germany) to the closest 0.1 mm by a calibrated examiner (E.B.), who measured up to 10 pairs of dental casts each day to avoid eye fatigue.[29-31] If the second measurement differed from the first by more than 0.2 mm, the tooth was measured again, and this third measurement was registered.[30,31] If the difference between both measurements was less than 0.2 mm, the first measurement was registered.[29-31]

Replicated measurements separated by 24 hours in 5 randomly selected pairs of dental casts were made by the primary examiner (E.B.) and an experienced orthodontist (C.F.) for detecting systematic error in the measurements; however, paired-sample *t* tests did not show any statistically significant differences for the intra-examiner and interexaminer measurements ($P > .181$ and $> .076$ respectively). Intra-examiner and interexaminer intraclass correlation coefficients were calculated ($r > 0.90$ and > 0.93, respectively) and statistically different from zero ($P < .001$ in both cases).

One-way ANOVA or Kruskal-Wallis tests were used to compare MD and BL tooth sizes, crown proportions, and arch dimension means among the 3 groups. The specific test was selected based on the normality criterion (Kolmogorov-Smirnov test) and the homogeneity of variances between groups (Levene test).

Furthermore, a descriptive stepwise multiple discriminant analysis (SMDA) was applied to determine the intra-arch occlusal characteristics that best discriminated between the 3 groups and their respective contributions to the variability in the dental arch discrepancies once suppositions of normality, homoscedasticity, and linearity were proved.

RESULTS

The distribution of the sample according to sex, dental arch, and crowding is shown in Table I. A comparison of all MD and BL tooth sizes between hemiarches was made. No difference for MD and BL tooth sizes between right and left sides of each arch was found (independent-sample *t* tests, $P > .085$ and $P > .317$ for the maxillary and mandibular arches, respectively). Based on these findings, only right-side measurements were considered.

Differences in MD tooth size were found for the first premolar ($P = .007$) and the central incisor ($P = .005$) in the maxillary arch, and the second premolar ($P = .018$), the canine ($P = .028$), and the lateral incisor ($P = .003$) in the mandibular arch when the 3 groups were compared. Comparisons of maxillary and mandibular BL tooth sizes had no statistically significant differences ($P > .434$ and $P > .070$ for the maxillary and mandibular arches, respectively) between groups.

In relation to the crown proportions (Peck and Peck index), differences were found only for the crown proportions of the canine ($P = .030$) in the maxillary arch and the first molar ($P = .038$), the canine ($P = .013$), and the lateral incisor ($P = .005$) in the mandibular arch.

Arch dimensions (intercanine and intermolar width, and arch length) were also compared among the 3 groups. Intermolar width ($P = .010$ and $P = .006$ for the maxillary and mandibular arches, respectively) and arch length ($P = .001$ and $P < .001$, respectively)