

Prevalence of Short Root Anomaly in a Group of Puerto Ricans

Christian Herrera, DDS, MSD*; Sona Rivas-Tumanyan, DMD, DrPH†; Jose Morales, DMD‡; Omar García-Rodríguez, DrPH§ Augusto R. Elías-Boneta, DMD, MSD, DHC¶

Objective: To estimate the prevalence of short root anomaly (SRA) in a group of Puerto Ricans at the Advanced Education Program in Orthodontics of the University of Puerto Rico.

Methods: A cross-sectional study was conducted with digital panoramic x-rays of 203 patients (112 females and 91 males; mean age: 17 years) in Puerto Rico. Utilizing the modified Lind's method, 406 maxillary right and left central incisors (1) were measured and evaluated for SRA. Root and crown length and R/C ratio were compared by sex and side. Linear regression was used to evaluate the associations between the R/C ratio and age, sex, and side (right/left). All the statistical analyses were evaluated using significance level of .05 (2).

Results: The prevalence of SRA was 0.49%. The average root and crown lengths for the maxillary right and left central incisors were 19.47 and 10.28 mm, respectively. Sex was associated with root and crown length, not with the R/C ratio. No differences were observed in the R/C ratio by the side. There were no significant associations between age, sex, and side and R/C ratio in the multivariate analysis.

Conclusion: The prevalence of SRA in our population is lower than any reported in the literature. The R/C ratio in our Hispanic population was the highest compared with those of other ethnicities. Neither the sex nor the side of the incisor was associated with the R/C ratio. These findings are contrary to those of prior reports stating that males have higher R/C ratios than females. [*P R Health Sci J* 2021;40: 115-119]

Key words: Short Root Anomaly, Root to Crown ratio, Panoramic Radiographs, Root Length, Crown Length

Short root anomaly (SRA) is a rare condition with an unknown etiology, 0.6% to 10% prevalence (1,2,3). SRA is defined as root-crown (R/C) ratios lower than 1.1 (1). Several studies have suggested that unfavorable R/C ratios caused by short dental roots are associated with a developmental deficiency (3), root resorption after orthodontic treatment (4), and dental trauma (5). The literature also has reported that female patients are more likely to develop this condition than are their male counterparts (1). In addition, developmentally short-rooted permanent teeth may be attributed to genetic factors (6). SRA is highly segregated in affected families (7). Moreover, hypoparathyroidism (8) and the Laurence–Moon–Bardet–Biedl (9), Stevens-Johnson (10), Down (11), and Turner (12) syndromes are linked to SRA. On the other hand, several environmental factors related to SRA have been proposed, such as irradiation of the neck and chemotherapy (13) of childhood malignancies (14) during tooth development.

Determining an R/C ratio is essential for many dental/orthodontic clinical procedures. An unfavorable R/C ratio can impact prosthodontic or orthodontic treatment plans, which, in turn, may complicate the prognosis of the teeth being treated

(15). Thus, addressing the R/C ratio and SRA is crucial in orthodontic patients because short roots tend to experience root resorption during orthodontic treatment (16).

In obtaining accurate measures, linear R/C measurement and projection radiography are unreliable; the R/C ratio gives healthcare personnel a clearer dental picture than the previous techniques (4). Radiographic angulation changes may affect the tooth length measured by radiographs, but this effect is not

*Former Resident Advanced Education Program in Orthodontics, School of Dental Medicine, University of Puerto Rico Medical Sciences Campus, San Juan, PR; †Office of Assistant Dean of Research, Associate Professor School of Dental Medicine, University of Puerto Rico Medical Sciences Campus, San Juan, PR; ‡Director Advanced Education Program in Orthodontics, School of Dental Medicine, University of Puerto Rico Medical Sciences Campus, San Juan, PR; §Consultant in epidemiology for Assistant Dean of Research, School of Dental Medicine, University of Puerto Rico Medical Sciences Campus, San Juan, PR; ¶Assistant Dean of Research, School of Dental Medicine, Medical Sciences Campus, University of Puerto Rico

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Address correspondence to: Augusto R. Elías-Boneta, DMD, School of Dental Medicine, Medical Sciences Campus, University of Puerto Rico, Puerto Rico. Email: augusto.elias@upr.edu

seen in the R/C ratio. In clinical settings, panoramic radiographs have proven helpful in determining R/C ratios. (17). In 2000, Stramotas et al. showed that crown height, root length, and R/C ratio could be measured reliably and accurately on these panoramic images (18).

Currently, there is only one study addressing R/C ratios in Hispanics. Our study found that Hispanics had lower R/C ratios for most of their teeth than Caucasians and African Americans did (19). However, the authors did not estimate the prevalence of SRA (in Hispanics) in their study.

Due to the lack of studies assessing the prevalence of SRA in different populations, specifically in Hispanics, our research group—members of the Advanced Education Program in Orthodontics (APO) at the University of Puerto Rico—aimed to determine the prevalence of SRA in a group of Puerto Rican dental patients. The present study's findings will provide insight into better management and treatment of patients seeking orthodontic treatment to reduce complications during treatment, resulting in better outcomes.

Materials and methods

A cross-sectional study was conducted on patients aged 10 to 31 seeking treatment from the APO at the University of Puerto Rico from 2012 to 2018. The study was approved by the University of Puerto Rico, Medical Science Campus Institutional Review Board (IRB) to fulfill the Declaration of Helsinki (Protocol #0640217). Panoramic radiographs of patients were randomly selected from the program's dataset. The present study included individuals born in Puerto Rico (self-reported Hispanics) with permanent maxillary right and left central incisors having fully formed and closed root apices. Patients were excluded from the study if they (1) had a previous history of dental trauma, (2) had undergone a root canal treatment in the maxillary central incisors, (3) showed variations in the shape of the teeth adjacent to the maxillary right and left central incisors (maxillary laterals), (4) had their maxillary right and left central incisors restored, (5) had radiographic evidence of apical reabsorption attributed to previous orthodontic treatment, (6) had a panoramic radiograph that evidenced one or more impacted maxillary canines, (7) or had poor-quality digital panoramic radiograph. The radiographs of 203 patients were included in the present study. The maxillary right and left central incisors (406 teeth from the 203 patients) were measured and then analyzed. Using the SIDEXIS XG system, Lind's (1,2) method was applied to measure the teeth of patients' panoramic x-rays. Crown height (Crh) is defined as the perpendicular line from a given midpoint on the CEJ (m), where m is the visually determined midpoint of a straight line connecting the points of intersection between the mesial and distal outer contours of the tooth crown (3); down to the incisal reference line (i). The root length (Rl) is described as the distance from m up to the apical reference line (a), which is parallel to i. A short root anomaly is defined as an R/C ratio of 1.1 or lower (1), Figure 1.

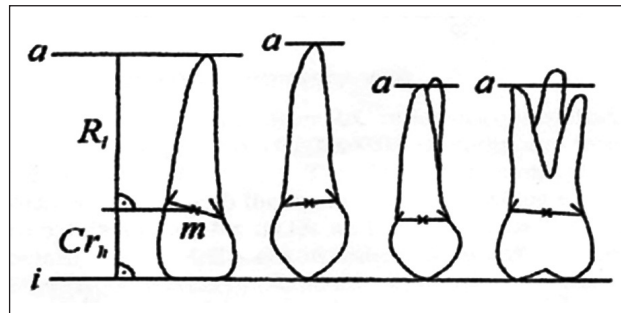


Figure 1. The method for measuring crown height and root length in the assessment of the root-crown (R/C) ratio (Adapted from Lind, 1972).

Training and calibration exercise

To assess intra-examiner reliability, the panoramic radiographs of 20 patients (40 teeth: left and right central incisors) from the APO at the University of Puerto Rico were randomly chosen (using a computerized list of random numbers) and then measured. For the training and calibration exercise, we used the aforementioned inclusion and exclusion criteria and methodology. Before carrying out the calibration, both examiners were trained on how to conduct the measurements on ten panoramic radiographs, utilizing the digital measure length tool provided by the software. If differences were identified, they were discussed, and a consensus was reached. Then, the PI and second examiner measured 20 panoramic radiographs independently, once at baseline and once within the following week.

The measurements were entered into an MS Excel file for further statistical analysis. To assess inter-examiner reliability, an intraclass correlation coefficient (ICC) was calculated for the root and crown lengths of the left and right maxillary central incisors. In addition, to examine the intra-examiner reliability regarding root length, crown length, and R/C ratio measurements in both teeth (left and right maxillary central incisors), Spearman's correlation coefficients were computed.

The findings of the calibration exercise are presented in Table 1. Our results showed that there was excellent intra-examiner reliability of measurements, with a statistically significant ($P < .001$) correlation between repeated readings. In addition, a high inter-reliability was also found ($ICC > 0.80$) (18).

Sample size calculation

Previous reports found the prevalence of SRA ranges from 0.6% to 10% among Caucasians (1,2). We assumed that the prevalence range among Caucasians would be similar in our sample. We also assumed that the precision of prevalence would range from 1 to 5%. Furthermore, to calculate the sample size, the statistical power was set to at least 80%, alpha (α) = 0.05 as a level of statistical significance. A total of 203 participants (406 teeth) were required to fulfill the aim of this study.

Table 1. Inter and Intra Examiner reliability of radiographic readings of root length, crown length, and root-to-crown ratio

Measure	Inter-examiner reliability	Intra-examiner reliability			
		Reference examiner		Second examiner	
	ICC	Spearman correlation coefficient	p-value	Spearman correlation coefficient	p-value
Root length, UR1	0.90	0.86	<0.0001	0.88	<0.0001
Crown length, UR1	0.91	0.84	<0.0001	0.85	<0.0001
Root-to-Crown ratio, UR1	0.89	0.86	<0.0001	0.94	<0.0001
Root length, UL1	0.94	0.87	<0.0001	0.94	<0.0001
Crown length, UL1	0.85	0.89	<0.0001	0.73	<0.0001
Root-to-Crown ratio, UL1	0.89	0.83	<0.0001	0.90	<0.0001

Statistical analyses

Continuous variables-root and crown length (mm) and R/C ratio were summarized with means (standard deviations and 95% confidence intervals) and medians (interquartile range). Descriptive analysis was performed for the categories of sex (male, female) and side (left, right). The normality of the continuous outcomes was tested using the Shapiro–Wilk normality test. Since all clinical measurements deviated from normality, a non-parametric Wilcoxon signed rank-sum test was used to compare their distribution by the side of the mouth (right vs. left). To compare the clinical measurements between males and females, a Mann–Whitney test was conducted.

Linear regression analysis was used to associate the R/C ratio with age, sex (male vs. female), and the side of the mouth (right vs. left) on which a given incisor was found. All tooth-level analyses accounted for within-person clustering of measurements in the individuals; regression coefficients (β) and their 95% confidence intervals (CIs) were reported. All analyses were conducted with α = 0.05 (level of statistical significance), using SAS statistical software, version 9.3 (SAS Statistical Institute, Cary, NC). This protocol was approved by institutional review board of the University of Puerto Rico, Medical Sciences Campus; it complies with the Declaration of Helsinki.

Results

The mean age of the patients was 17 (± 4.77) years, with a minimum of 10 and a maximum of 31 years. As seen in Table 2, in all the measured teeth, the mean lengths of the roots and the crowns were 19.47 mm (95% CI: 19.17–19.77) and 10.28 mm (95% CI: 10.17–10.39), respectively. The average R/C ratio was 1.90 (95% CI: 1.87–1.93) and ranged from 0.96 to 2.52 (Table 2). There was one participant who presented SRA, representing 0.49% of the sample in the present study.

No differences were found between left and right maxillary central incisors in terms of root length, crown length, or R/C ratio (Table 3, all P > .05). Male participants had longer roots and crowns (Table 4, mean root length: 20.02 mm, 95% CI: 19.65–20.48; mean crown length: 10.55 mm, 95% CI: 10.38–10.71) than female participants did (mean root length: 19.02 mm, 95% CI: 18.63–19.40; and mean crown length: 10.06 mm, 95% CI: 9.92–10.20; P < .0001). However, there was no difference in root-to-crown ratio by sex (mean ratio: 1.91, 95% CI: 1.86–1.96 for males and 1.90, 95% CI: 1.86–1.94 for females; P = .64).

Multivariate linear regression analysis did not evidence an association between age, sex, or side and root-to-crown ratio (Table 5).

Discussion and Conclusion

This study aimed to estimate (tooth) root and crown lengths and their ratios in a sample of Puerto Ricans. We also calculated the prevalence of SRA in the sample.

Earlier investigations in a Caucasian population have estimated that SRA prevalence ranges from 0.6% to 2.7%

Table 2. Distribution of radiographically measured root length, crown length, and root-to-crown ratio for central incisors (n=406)

Measure	Mean (95% Confidence Interval)	Median (Inter-Quartile Range)
Root length, mm	19.47 (19.17- 19.77)	19.44 (17.91 – 20.82)
Crown length, mm	10.28 (10.17-10.39)	10.25 (9.60 – 10.84)
Root-to-crown ratio	1.90 (1.87-1.93)	1.91 (1.73 – 2.08)

Table 3. Distribution of radiographically measured root length, crown length, and root-to-crown ratio for central incisors by side

Measure	Left (n=203)		Right (n=203)		p-value*
	Mean (95% Confidence Interval)	Median (Interquartile Range)	Mean (95% Confidence Interval)	Median (Interquartile Range)	
Root length, mm	19.40 (19.08 – 19.72)	19.47 (17.92 – 20.68)	19.53 (19.22 – 19.84)	19.43 (17.91 – 21.07)	>.10
Crown length, mm	10.29 (10.17 – 10.41)	10.23 (9.64 – 10.88)	10.27 (10.15 – 10.39)	10.27 (9.57 – 10.80)	>.64
Root-to-crown ratio	1.89 (1.86 – 1.93)	1.89 (1.74 – 2.07)	1.91 (1.88 – 1.94)	1.93 (1.73 – 2.08)	>.22

*Wilcoxon signed rank sum test

Table 4. Distribution of radiographically measured root length, crown length, and root-to-crown ratio for central incisors, by participant's sex

Measure	Male (n=182)		Female (n=224)		p-value*
	Mean (95% Confidence Interval)	Median (Interquartile Range)	Mean (95% Confidence Interval)	Median (Interquartile Range)	
Root length, mm	20.02 (19.56 – 20.48)	20.04 (18.74 – 21.42)	19.02 (18.63 – 19.40)	18.90 (17.53 – 20.30)	<0.0001
Crown length, mm	10.55 (10.38 – 10.71)	10.49 (9.94 – 11.09)	10.06 (9.92 – 10.20)	10.01 (9.42 – 10.63)	<0.0001
Root-to-crown ratio	1.91 (1.86 – 1.96)	1.91 (1.73 – 2.09)	1.90 (1.86 – 1.94)	1.92 (1.73 – 2.09)	=.64

*Mann-Whitney test

Table 5. Regression coefficients (95% confidence intervals) for root-to-crown ratio, according to age, sex, and side of the tooth

Characteristic	β	95% CI
Age (years)	0.002	(-0.005; 0.009)
Sex		
female vs. male (ref.)	-0.014	(-0.079; 0.051)
Side		
left vs. right (ref.)	-0.016	(-0.038; 0.007)

(1,2,3,20,21). The SRA prevalence in a Mongolian population has been estimated to be as high as 10% (1,6,7). A more recent study assessing randomly selected panoramic radiographs of 1,953 university Caucasian students showed a prevalence of 1.3% (19). The prevalence of SRA in our study was estimated to be 0.49%; however, comparisons with other populations should consider methodological differences between studies, such as the main outcome measurement and the inclusion/exclusion criteria of the patients.

The existing data on the R/C ratio are limited to Caucasians (19), Koreans (21, 22), Iranians (24), and Hispanics (19). The last showed significantly lower ratios in most of their teeth than African Americans and Caucasians in their upper lateral incisors, lower central incisors, and lower first premolars.

To date, the findings in the study described herein present the highest reported R/C ratio worldwide.

Because only one of the men who participated in our study had SRA, we could not evaluate sex differences in SRA prevalence. In a previous study conducted in Caucasians, SRA was more prevalent in females than males (3). Similar to Lind's and Jakobsson's study (in Caucasians) (1), our research findings observed no sex differences when comparing the R/C ratios of maxillary central incisors. However, other studies, including Caucasians (3), African Americans (19), Koreans (22, 23), and Iranians (24), found that sex is associated with the R/C ratio, with males reported to have higher R/C ratios than females.

We found no difference between the R/C ratio in the right and the left incisors. Our results align with those presented in the Korean (22) population study.

The present study had several limitations. We cannot extrapolate our findings to the general population of Puerto Rico since the study sample was selected from one orthodontic clinic. Therefore, estimates for the general population may be different from those obtained in our study. As mentioned above, different measurement techniques were employed in other studies. Nevertheless, to our knowledge, this is the first study in Puerto Rico and the rest of the Caribbean to address SRA.

More studies are needed to assess the proposed method and the underlying causes and risk factors for SRA. The assessment of the R/C ratio may be a valuable tool to identify the short roots before starting orthodontic treatment, determine the progression/regression of apical root resorption due to dental trauma, and measure the extent of root shortening in some syndromes and conditions.

The prevalence of SRA found in our study is the lowest reported in the literature. In this study of a Hispanic population, we reported the highest R/C ratio compared to what has been reported by studies looking at other ethnicities. Although the male sex was associated with longer root and crown measurements, we found no evidence of its association with the R/C ratio. The side of the mouth on which a given tooth was found was not associated with the R/C ratio. These findings are contrary to the prior studies stating that males have higher R/C ratios than females.

Resumen

Objetivo: Estimar la prevalencia de la anomalía de raíz corta (SRA) en un grupo de puertorriqueños del Programa de Educación Avanzada en Ortodoncia de la Universidad de Puerto Rico. **Métodos:** Se realizó un estudio transversal con radiografías panorámicas digitales de 203 pacientes (112 mujeres y 91 hombres; edad promedio: 17 años). Utilizando el método de Lind modificado, 406 incisivos centrales superiores derecho e izquierdo (1) se midieron y evaluaron para SRA. La longitud de la raíz, la corona y la proporción de R/C se comparó por sexo y lado (derecho / izquierdo). Mediante regresión lineal se estudió la asociación entre R/C y la edad, el sexo y el lado. Todo análisis estadístico fue evaluado usando un nivel de significancia de .05. **Resultados:** Encontramos una prevalencia de ARC de 0,49%. En promedio las longitudes de raíz y corona de los incisivos centrales superiores fueron 19.47 y 10.28 mm, respectivamente. El sexo se asoció con la longitud de raíz y corona, pero no se encontró relación con R/C ni diferencias significativas entre la relación R/C por el lado ni asociación con la edad, sexo y lado. **Conclusión:** La prevalencia de ARC es la más baja reportada en la literatura, la razón de R/C en la población hispana fue la más alta comparada

con otras etnias. Ni el sexo ni el lado del incisivo maxilar (derecho o izquierdo) se asociaron con la razón de R/C. Estos hallazgos difieren a publicaciones anteriores donde reportan proporciones R/C más en el sexo masculino comparado con femenino.

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