

Comparison of Chu's Proportion Gauge with a T-bar Tip and a Two-Tip Compass in the Determination of Anterior Dentition Tooth Size in a Group of Puerto Ricans

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Objective: Compare maxillary anterior dentition measurements, using Chu's proportion gauge with a T-bar tip (PG-TT) and a Two-Tip Compass (T-TC), in a group of Puerto Ricans, to determine the reliability of the PG-TT.

Methods: This cross-sectional study was conducted at the University of Puerto Rico, School of Dental Medicine, Medical Sciences Campus. The participants (18–35 years old) were dental students or employees of the university. Previously, the examiner had been trained and calibrated in instrument usage. Calibration participants (n = 16) received an oral exam, prophylaxis, and a chlorhexidine mouthwash for home use. After 3 days, the upper-anterior teeth were measured using the 2 instruments. The agreement was determined using weighted kappa statistics (Kw), and 0.80 was the minimum acceptable level. The examiner achieved almost perfect agreement (inter-examiner KwT-TC = 0.95 [0.96–0.93]; KwPG-TT = 0.82 [0.81–0.87]) with a reference examiner.

Results: Fifty participants (25 women and 25 men) were evaluated. **Length:** The teeth of the men presented an unacceptable level of agreement, except for in the right central incisors. For the women, a strong level of agreement was observed only in the lateral incisors and left canines. When the teeth of both sexes were considered, a strong level of agreement was detected, except for in the right canines and left central incisors. **Width:** The level of agreement was unacceptable, except for in the right canines (distal).

Conclusion: T-TC is a more reliable instrument to measure tooth dimensions as compared to the PG-TT. [*P R Health Sci J* 2020;39:288-293]

Key words: Tooth size, Odontometry, T-Bar Proportion Chu's Gauge, Crown lengthening, Puerto Rico

Determination of tooth dimension is important in esthetic/restorative dentistry (1,2), planning for crown lengthening (3,4), orthodontic treatment procedures (5,6), forensic dentistry (7,8), and anthropology (9). Failure to achieve accurate tooth-size proportions (mesiodistal width and inciso-cervical length) affects the patient's smile and appearance (4). Therefore, tooth size must be addressed to attain a predictable esthetic outcome (1).

There are 2 main concepts regarding tooth length: 1. absolute size—clinical or anatomical crown length and width—expressed in millimeters and 2. the position of the incisal edge relative to the internal border of the lower lip when smiling (10). Tooth length (absolute and relative) could be affected by delayed passive eruption and conditions resulting in incisal wear, including attrition, abrasion, erosion, and incisal fracture (11,12).

Traditionally, tooth-size determination is conducted by using a compass and a caliper (13). However, this process is

tedious since length and width need to be measured separately for each tooth. In 2007, Stephen Chu developed the T-Bar Proportion Gauge (PG-TT), a tool used to determine the correct length relative to the width (which ratio is called the golden proportion) simultaneously using the guidelines for smile design (3). The measurements of the PG-TT were based on clinical studies of range and mean distribution values of individual tooth size and established anatomic and clinical

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proportion ratios; width values were found in an *in vitro* study using diagnostic dental casts (14). According to these studies, during esthetic reconstruction, these proportion values can be applied to their respective sex group with a feasible level of confidence (70% for males and 60% for females) (14).

Owing to the known limitations of *in vitro* studies, there is a need to evaluate whether the PG-TT tip provides a reliable and predictable measure of esthetic tooth proportion. Therefore, the aim of this study was to compare the accuracy of the PG-TT tip to that of the gold standard Two-Tip Compass in a group of 15- to 35-year-olds residing in Puerto Rico.

Methods

This observational cross-sectional study was conducted at the University of Puerto Rico (UPR) School of Dental Medicine research clinic from July 2014 through October 2014. The study was approved by the UPR Medical Sciences Campus institutional review board.

Before the study, a training and calibration exercise on the use of the instruments was conducted at the University of Costa Rica Prosthodontics Postgraduate Program in San José, Costa Rica. A prosthodontist with ample experience using both instruments, Dr. Ottón Fernández López, served as the reference examiner. In this exercise, a total of 20 subjects were screened of which 16 (8 males and 8 females) were evaluated. The examiner achieved almost perfect agreement (inter-examiner weighted kappa [Kw] for the T-TC: 0.95 [0.93–0.96]; and for the PG-TT: 0.82 [0.81–0.87]) with the reference examiner with both instruments.

A convenience sample was selected at the UPR Medical Sciences Campus. Both dental students and employees of the UPR Medical Sciences Campus were invited to participate; those who agreed to do so signed an informed consent to take part in the clinical procedures. The consent of a parent was obtained, if required.

Inclusion criteria: being 18- to 35 years old, having an ASA of I (15), having well-aligned teeth (i.e., properly aligned with respect to their long axis). Exclusion criteria: having

had 1 or more maxillary anterior teeth restored; undergoing orthodontic treatment at the time of the study; having had interproximal stripping; having anterior crowding, indications of incisal attrition, delayed passive eruption (as determined during the clinical tooth measurement), or an incisal wear facet or fracture; and suffering from gingival inflammation/recession, visible signs of incisal attrition, diastemata, delayed passive eruption (as determined during the clinical tooth measurement), and incisal wear facet or fracture.

This 2-visit study was conducted by a calibrated examiner using 2.5x magnification dental loupes (SurgiTel, General Scientific Corp, Ann Arbor, MI). During the first visit, an oral exam (dental and soft tissue) was undertaken to address participant eligibility. Additionally, sulcus probing was done to verify the absence of a delayed passive eruption. Subjects who met the inclusion criteria received dental prophylaxis from the examiner dentist and were prescribed chlorhexidine gluconate (12%) rinses twice daily for 3 days to control gingival inflammation.

During the second visit, participants were seated on the dental chair in a supine position (horizontal position) while the examiner was in the direct rear position. The 6 maxillary anterior teeth—central incisors, lateral incisors, and canines—were measured independently. Length (cervico-incisal) and width (mesial-distal) were assessed using the PG-TT (Hu-Friedy Mfg. Co., LLC, Chicago, IL) and a two-tip, Korkhaus-type compass. A computer was employed to randomize the order in which the T-TC and PG-TT were used on each subject. All the assessments were carried out on the labial aspect of the teeth.

The PG-TT was used according to the manufacturer's instructions. Briefly, the instrument was centered on each tooth while the stop rested on the incisal edge of the incisor or the tip of the cusp of the canine (Fig. 1A). For the length evaluation, the color of the band of the vertical arm in contact with the gingival margin (cervical) was recorded. For width, the color of each of the bands on the horizontal arm in contact with the mesial and distal marginal ridges, respectively, was

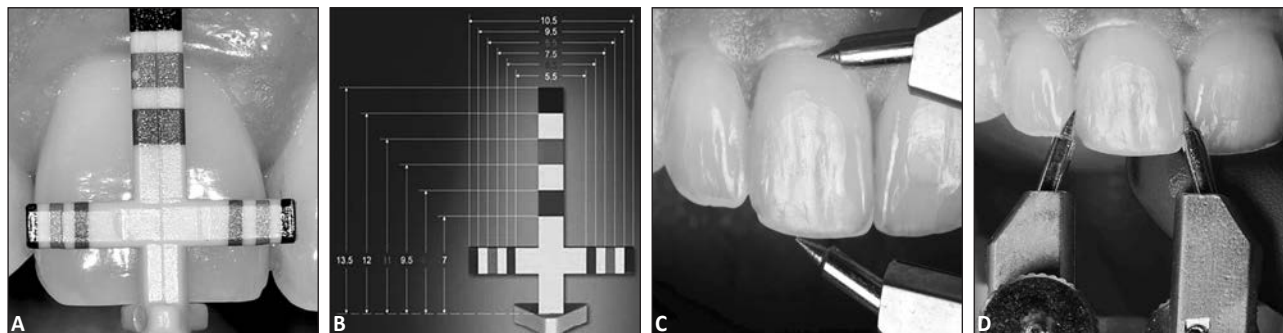


Figure 1. Chu's Proportion Gauge with a T-bar tip: A. Tooth width and length measured simultaneously. B. The numbers are organized on the horizontal arm from the inside to the outside (5.5–10.5 mm) and the vertical arm from the incisal stop to the top (7–13.5 mm). Two-Tip Compass: C. Mesiodistal measurement (width); D. Incisocervical measurement (length).

registered. The resulting measures (width/length intervals in mm) were categorized based on the following color-coded reference marks (Figure 1B): blue = 2.75–3.25/7–8.5; yellow (A) = 3.26–3.75/8.6–9.5; red = 3.76–4.25/9.6–11; yellow (B) = 4.26–4.75/11.6–12; black = 4.76–5.25/12.1–13.5. For width comparison, PG-TT–categorized color-coded reference marks were converted into numerical values by measuring the mesio-distal dimension, and the T-TC mesio-distal distance was divided by 2.

Regarding T-TC positioning, the arms of the instrument were placed in labial embrasures at the greatest mesiodistal breadth of each tooth for width (Fig. 1C) and at the largest inciso-cervical dimension, parallel to the tooth’s long axis, for length (Fig. 1D). Measures were expressed in millimeters. The measures obtained with the T-TC were then transferred to a sheet of wax paper by pressing the 2 points of the compass into it, and then the distance between the points was measured using a digital caliper (Mitutoyo America Corporation, Aurora, IL). Before each measurement, the digital caliper was disinfected, calibrated, and zeroed out.

All the measurements were then recorded on 2 evaluation forms, 1 for each instrument, by a dental student. All the measurements were repeated in 10% of the participants in a subsequent visit, conducted at least 3 days after the initial visit to verify intra-examiner reliability. On the repeated examinations, the intra-examiner agreement for the T-TC was 0.98 (CI 0.98–0.99); for the PG-TT, it was 0.85 (CI 0.84–0.91).

Statistical analysis

Distribution frequencies (mean, minimum, maximum, and median) of individual tooth width and length for the maxillary central, lateral, and canine teeth were calculated, as were comparative distribution frequencies according to sex. The agreement between the T-TC compass and the PG-

TT measurements was calculated using a weighted kappa (Kw). To calculate the Kw, the T-TC compass measurements were divided by 2 for both tooth width and length for the maxillary central, lateral, and canine teeth. After dividing these measurements, we classified them into 5 categories: blue = 2.75–3.25 mm/7.00–8.5 mm, yellow [A] = 3.26–3.75 mm/8.6–9.5 mm, red = 3.76–4.25 mm/9.6–11.00 mm, yellow [B] = 4.26–4.75 mm/11.6–12.00 mm, and black = 4.76–5.25 mm/12.1–13.5 mm).

A Kw was computed for tooth width and length by determining whether the categorized values of the T-TC compass were comparable with those obtained for the PG-TT. A Kw of 0.80 or greater (strong = 0.80–0.90; almost perfect >0.90) was considered an acceptable agreement level (16). The data were analyzed using STATA 9.0 software.

Results

A total of 80 subjects were assessed for eligibility. Thirty of them did not meet the inclusion criteria. Fifty participants, 25 males and 25 females (68% were students and 32% were employees; mean age 25.02 years), completed the 2 visits.

Table 1 shows the mean, minimum, maximum, and median width and length measurements obtained using the T-TC. Overall, the mean width ranged from 7.23 mm (right lateral incisors) to 8.86 mm (left central incisors). The mean length ranged from 9.10 (right lateral incisors) to 10.62 (left central incisors). The mean values indicate that males had wider and longer anterior teeth than did females.

Table 2 illustrates the percentage of teeth within each color’s corresponding dimension range (width and length). The canines and central incisors of most of the female participants fell within the red and yellow (B) ranges, whereas those of the male participants were primarily within the yellow (B) range, followed by the black range. Regarding the

Table 1. Anterior tooth dimensions¹ in a group of Puerto Ricans measured using a Two-tip compass

		Right Canine		Right Lateral Incisor		Right Central Incisor		Left Central Incisor		Left Lateral Incisor		Left Canine	
		Width	Length	Width	Length	Width	Length	Width	Length	Width	Length	Width	Length
Female	Mean	7.88	9.72	7.10	8.81	8.59	10.19	8.65	10.29	7.16	9.07	7.82	9.83
	Minimum	7.02	8.07	5.93	7.40	7.46	8.45	7.28	8.58	5.58	7.71	6.79	7.97
	Maximum	8.92	11.29	7.88	10.50	9.44	11.75	9.40	11.9	7.97	11.09	8.79	11.81
	Median	7.85	9.55	7.08	8.82	8.67	10.21	8.69	10.19	6.94	8.80	7.83	9.69
Male	Mean	8.36	10.69	7.36	9.40	9.05	10.82	9.06	10.95	7.41	9.50	8.26	10.75
	Minimum	7.66	9.57	6.13	7.57	8.07	9.26	8.27	9.61	6.47	7.43	7.58	8.90
	Maximum	9.15	12.03	8.05	10.9	10.47	12.31	10.53	12.31	8.08	11.09	9.00	12.69
	Median	8.28	10.64	7.46	9.37	9.11	11.02	8.80	10.92	7.56	9.37	8.29	10.76
All	Mean	8.12	10.2	7.23	9.10	8.82	10.5	8.86	10.62	7.24	9.29	8.04	10.29
	Minimum	7.02	8.07	5.93	7.40	7.46	8.45	7.28	8.58	5.58	7.43	6.79	7.97
	Maximum	9.15	12.30	8.05	10.9	10.47	12.31	10.53	12.31	8.08	11.09	9.00	12.69
	Median	8.04	10.24	5.93	9.09	8.71	10.63	8.75	10.77	7.35	9.19	7.99	10.33

¹in mm

Table 2. Ranges¹ of anterior tooth dimensions in a group of Puerto Ricans measured using a Proportion Gauge with a T-bar tip

	Right Canine		Right Lateral Incisor		Right Central Incisor		Left Central Incisor		Left Lateral Incisor		Left Canine							
	Width		Length		Width		Length		Width		Length							
	Mesial	Distal	Mesial	Distal	Mesial	Distal	Mesial	Distal	Mesial	Distal	Mesial	Distal						
C-CR ¹																		
Blue	0%	0%	12%	16%	28%	36%	0%	0%	0%	0%	0%	0%	36%	12%	44%	0%	0%	8%
Yellow (A)	0%	0%	4%	68%	56%	36%	0%	0%	16%	0%	4%	8%	40%	52%	8%	12%	0%	28%
Female Red	88%	88%	72%	16%	16%	28%	32%	36%	60%	40%	32%	68%	20%	36%	48%	72%	92%	48%
Yellow (B)	12%	12%	12%	0%	0%	0%	60%	56%	20%	56%	52%	16%	4%	0%	0%	16%	8%	16%
Black	0%	0%	0%	0%	0%	0%	8%	8%	4%	4%	12%	8%	0%	0%	0%	0%	0%	0%
Male Blue	0%	0%	0%	8%	8%	12%	0%	0%	0%	0%	0%	0%	12%	0%	16%	0%	0%	0%
Yellow (A)	0%	0%	0%	44%	52%	36%	0%	0%	4%	0%	0%	0%	48%	36%	28%	4%	0%	4%
Red	60%	64%	72%	44%	36%	44%	16%	12%	44%	16%	12%	44%	40%	60%	48%	52%	60%	68%
Yellow (B)	36%	36%	28%	4%	4%	8%	52%	60%	44%	56%	60%	52%	0%	4%	8%	44%	40%	20%
Black	4%	0%	0%	0%	0%	0%	32%	28%	8%	28%	28%	4%	0%	0%	0%	0%	0%	8%

¹color-code reference dimension ranges (width/length in mm): blue = 2.75–3.25/7–8.5; yellow (A) = 3.26–3.75/8.6–9.5; red = 3.76–4.25/9.6–11; yellow (B) = 4.26–4.75/11.6–12; black = 4.76–5.25/12.1–13.5. ²percentage of participants within each dimension range.

lateral incisors, for both sexes, the highest percentages were in the range represented by the color red.

Regarding tooth length, the levels of agreement between the PG-TT and the TTP measures are displayed in Table 3. Overall (i.e., in both sexes), acceptable agreement (Kw: >0.80)

Table 3. Weighted kappa (Kw) between Proportion Gauge with a T-bar tip and Two-Tip Compass in tooth length

Tooth	Male (n = 25)	Female (n = 25)	Both Sexes (n = 50)
Right Canine	0.66	0.77	0.77
Right Lateral Incisor	0.71	0.84*	0.80*
Right Central Incisor	0.91*	0.79	0.86*
Left Central Incisor	0.72	0.64	0.70
Left Lateral Incisor	0.77	0.87*	0.84*
Left Canine	0.75	0.84*	0.83*

*Kw ≥ 0.80 indicates an acceptable agreement level

Table 4. Weighted kappa (Kw)* between Proportion Gauge with a T-bar tip and Two-Tip Compass in mesial tooth width.

Tooth	Male (n = 25)	Female (n = 25)	Both Sexes (n = 50)
Right Canine	0.72	0.47	0.67
Right Lateral	0.40	0.67	0.55
Right Central	0.61	0.70	0.68
Left Central	0.52	0.67	0.63
Left Lateral	0.65	0.25	0.48
Left Canine	0.56	0.35	0.53

*Kw ≥ 0.80 indicates an acceptable agreement level

was detected, except for in the right canine (Kw: 0.77) and left central (Kw: 0.70) teeth. For males, the level of agreement in all teeth was unacceptable (Kw: <0.80), except for in the right central (Kw: 0.91) teeth. For females, an acceptable agreement was observed only in the right lateral (Kw: 0.84), left lateral (Kw: 0.87), and left canine (Kw: 0.84) teeth.

Table 4 shows the levels of agreement for the measurements of mesial width. The levels of agreement (Kw) were unacceptable, ranging from 0.25 (females, left laterals) to 0.72 (males, right canines). When the measurements of the teeth of both sexes were analyzed, the levels of agreement between the instrument measurements were unacceptable, ranging from 0.48 to 0.68.

The agreement levels between the PG-TT and the T-TC measurements for distal width are depicted in Table 5. The agreement (Kw) in distobuccal of the anterior teeth was unacceptable, ranging from 0.26 (males, right canines) to 0.68

Table 5. Weighted kappa (Kw)* between Proportion Gauge with a T-bar tip and Two-Tip Compass in distal tooth width.

Tooth	Female (n = 25)	Male (n = 25)	Both Sexes (n = 50)
Right Canine	0.83*	0.26	0.62
Right Lateral Incisor	0.28	0.68	0.51
Right Central Incisor	0.57	0.65	0.64
Left Central Incisor	0.44	0.56	0.55
Left Lateral Incisor	0.35	0.49	0.48
Left Canine	0.48	0.33	0.51

*Kw ≥ 0.80 indicates an acceptable agreement level

(males, right lateral incisors); however, it was strong (0.83) for the right canines in females. When both sexes were analyzed, the agreements (Kw) between the instrument measurements were unacceptable, ranging from 0.48 to 0.64.

Discussion

This study aimed to compare the use of the PG-TT and the T-TC in determining tooth-size proportions in a group of 18- to 35-year-old Puerto Ricans by type of incisor and sex. To the best of our knowledge, this is the first clinical study comparing the performance of the PG-TT and the T-TC in determining the crown dimensions of the anterior dentition.

The results of our study suggest that the PG-TT is inadequate to measure anterior tooth length and width, as demonstrated by unacceptable levels of agreement for most of the measurements, particularly that of width. The faulty assessment of the dimensions of a patient's teeth can negatively affect that individual's appearance (e.g., smile) (1,17), oral function (2), periodontal health (4), treatment outcomes (5,6), or any combination of 2, 3, or all 4 elements.

The findings of the present study also made available tooth size dimension norms for a group of adult Puerto Ricans. Our results showed that the anterior teeth of Puerto Rican males tend to be longer and wider than are those of their female counterparts; nevertheless, we found no evidence of phenotypic dental variation(s) in the lateral incisors or canines in this population.

Radiographic studies have revealed odontometric dissimilarities linked to race and sex (18), as well as dimensional differences in diverse ethnic groups (19). A multicenter, interracial study of intraoral parameters reported no differences in maxillary right incisor width (the only dental measurement evaluated) among Hispanic, Korean, the Chinese, and Caucasian subjects; however, Hispanic, African American, and Caucasian males had wider maxillary right incisors than their female counterparts did (20). Regarding sex, a dental anthropology study has evidenced that the most dimorphic human tooth is the canine (9). This observation was confirmed recently in stone casts of the maxillary dentition (central incisor, canine, first premolar, and first molar) of young adults living in Indian (21).

An odontometry study conducted with casts from 150 young adults residing in Chile adds to the literature its findings that the mesiodistal dimension of the right maxillary lateral incisors was significantly wider in males compared to females (22). Using dental calipers, Srivastava et al. (2014) discovered that the mesiodistal dimensions of the right and left maxillary canines and central incisors were significantly greater in males compared to females (7). This mesiodistal dimorphism was recently confirmed with casts from 204 Jordanian adolescents, using a manual Vernier caliper (23). In contrast to what was found by these studies, the male and female study participants from Puerto Rico did not present tooth-specific differences.

Tooth size is influenced by genetic, environmental, and epigenetic factors (24). It has been reported that additive genetic variation—the inheritance of a particular allele from a parent—accounts for up to 92% of phenotypic differences in permanent crown dimensions (25). Therefore, the disagreement found in the present study could be attributed to the geographical diversity in the genetic admixture that exists in Puerto Rico (26). Additionally, the PG-TT was developed following the golden proportion (color codes are pre-set with a width/length ratio of 78%). It is possible that this proportion is not generalizable to all populations. Moreover, the T-TC is a quantitative instrument (measures exact numbers) and the PG-TT is a semi-quantitative instrument (assesses a range); therefore, the T-TC is more accurate and less uncertain than is the PG-TT.

Future studies need to be conducted using larger sample sizes and in other populations on the island to establish norms for permanent anterior dentition length and width in Puerto Ricans. Since the prevalence of tooth loss increases with age (27), additional studies in older subjects who are more likely to seek prosthodontic treatment and are more prone to present dental attrition are necessary. If our results are confirmed in other studies, new, tailored, simpler instruments and methods need to be developed for assessing tooth dimensions accurately to achieve better esthetic and/or restorative outcomes.

Conclusion

The PG-TT appears inadequate to measure the length and width of maxillary teeth in this Puerto Rican group. The T-TC remains the most reliable instrument to measure tooth dimensions. Failure to achieve accurate tooth-size proportions could affect a patient's smile and appearance.

Resumen

Objetivo: Comparar las mediciones de la dentición maxilar anterior utilizando "Chu's proportion gauge with a T-bar tip" (PG-TT) vs. un "Two-Tip Compass" (T-TC) en un grupo de puertorriqueños, para determinar la confiabilidad de T-BGP. Métodos: Este estudio transversal fue realizado en la Escuela de Medicina Dental de la Universidad de Puerto Rico, Recinto de Ciencias Médicas. Los participantes (18-35 años) eran estudiantes de odontología o empleados de la universidad. Previamente, el examinador fue entrenado y calibrado en el uso de los instrumentos. Los participantes de la calibración (n = 16) recibieron un examen oral, profilaxis, y enjuague bucal de clorhexidina (uso casero). Después de 3 días, se midió cada diente anterosuperior usando los 2 instrumentos. El acuerdo se determinó utilizando estadística kappa ponderada (Kw) y 0.80 fue el nivel mínimo aceptable. El examinador logró un acuerdo casi perfecto (Kw) entre examinadores= T-TC: 0.95 (0.96-0.93) y PG-TT: 0.82 (0.81-0.87), en comparación con un examinador de referencia. Resultados: Se examinaron 50 participantes (25 mujeres y 25 hombres). Longitud: los dientes

en hombres presentaron una concordancia no aceptable, con excepción de los centrales derechos. En mujeres, se observó un fuerte acuerdo solo en los laterales y los caninos izquierdos. Considerando ambos sexos, se detectó un fuerte acuerdo, excepto en los caninos derechos y en los centrales izquierdos. Ancho: el nivel de acuerdo fue inaceptable, excepto para los caninos derechos (distal). Conclusión: T-TC es un instrumento más confiable para medir las dimensiones de los dientes en comparación con el PG-TT.

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