

## Comparison of Two Methods, Lamendin and González-Colmenares, to Estimate Age in Adults \*

Comparación de dos métodos, Lamendin y González-Colmenares, para estimar la edad en adultos

Comparaçãõ de dois métodos, Lamendin e González-Colmenares, para estimar a idade em adultos

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### ABSTRACT

**Background:** The estimation of age through tooth study is one of the main tools to guide the identification of a cadaver. This process becomes more complex in adults because dental structures have already completed their development. Several methods for estimating dental age in adults are based on root transparency, being the developed by Lamendin, *et al.* (1992) one of the most studied worldwide. There is also one method that was developed for Colombian population: González-Colmenares (2007). **Purpose:** To identify correlations between real age and dentin translucency, real age, and periodontal recession using the Lamendin and González-Colmenares methods by city and combined cities (Bogotá and Medellín, Colombia). **Methods:** In this experimental, retrospective, and *in vitro* study, we performed linear regression models. Coefficients of determination ( $R^2$ ), coefficients of multiple connections, and intersection of the regression line with a 95 % confidence were calculated ( $p < 0.05$ ). **Results:** The Student's t test did not show significant differences between the two methods. The correlation between the biological and the estimated age was slightly more accurate with the González-Colmenares (2 %) than the Lamendin's method. **Conclusions:** Both methods showed similar accuracy to estimate age in adults. **Keywords:** age estimation; dental age; dentistry; forensic dentistry; human identification; periodontal recession; root length; root transparency

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### RESUMEN

**Antecedentes:** La estimación de la edad a través del análisis dental es una de las principales herramientas para orientar la identificación de un cadáver. Este proceso se vuelve más complejo en adultos debido a que las estructuras dentales ya han completado su desarrollo. Varios métodos para estimar la edad dental en adultos se basan en la transparencia radicular, siendo el desarrollado por Lamendin, *et al.* (1992) uno de los más estudiados mundialmente. También existe un método desarrollado para población colombiana: González-Colmenares (2007). **Objetivo:** Identificar correlaciones entre edad real y translucidez dentinaria, edad real y recesión periodontal utilizando los métodos de Lamendin y González-Colmenares por ciudad y

ciudades combinadas (Bogotá y Medellín, Colombia). **Métodos:** En este estudio experimental, retrospectivo e *in vitro*, realizamos modelos de regresión lineal. Se calcularon coeficientes de determinación ( $R^2$ ), coeficientes de conexiones múltiples e intersección de la línea de regresión con un 95 % de confianza ( $p < 0.05$ ). **Resultados:** La prueba t de Student no mostró diferencias significativas entre los dos métodos. La correlación entre la edad biológica y la estimada fue ligeramente más precisa con el método de González-Colmenares (2 %) que con el de Lamendin. **Conclusiones:** Ambos métodos mostraron similar precisión para estimar la edad en adultos.

**Palabras clave:** edad dental; estimación de la edad; identificación humana; longitud de la raíz; odontología; odontología forense; recesión periodontal; transparencia raíz

## RESUMO

**Antecedentes:** A estimativa da idade por meio do estudo dentário é uma das principais ferramentas para orientar a identificação de um cadáver. Esse processo torna-se mais complexo em adultos porque as estruturas dentárias já completaram seu desenvolvimento. Vários métodos para estimar a idade dentária em adultos são baseados na transparência radicular, sendo o desenvolvido por Lamendin, *et al.* (1992) um dos mais estudados em todo o mundo. Existe também um método que foi desenvolvido para a população colombiana: González-Colmenares (2007). **Objetivo:** Identificar correlações entre idade real e translucidez dentinária, idade real e recessão periodontal usando os métodos de Lamendin e González-Colmenares por cidade e cidades combinadas (Bogotá e Medellín, Colômbia). **Métodos:** Neste estudo experimental, retrospectivo e *in vitro*, realizamos modelos de regressão linear. Foram calculados os coeficientes de determinação ( $R^2$ ), coeficientes de conexões múltiplas e interseção da reta de regressão com 95% de confiança ( $p < 0,05$ ). **Resultados:** O teste t de Student não mostrou diferenças significativas entre os dois métodos. A correlação entre a idade biológica e a estimada foi ligeiramente mais precisa com o método de González-Colmenares (2%) do que com o método de Lamendin. **Conclusões:** Ambos os métodos mostraram acurácia semelhante para estimar a idade em adultos.

**Palavras-chave:** comprimento da raiz; estimativa de idade; idade dentária; identificação humana; odontologia; odontologia legal; recessão periodontal; transparência raiz

## INTRODUCTION

Age estimation is one of the main factors in determining the biological profile of a corpse (1). Teeth, being the most resistant structures in the human body, play a very important role in estimating the age of corpses that are difficult to identify. Once the individual reaches physical maturity and body development has finished, age estimation becomes one of the biggest challenges in forensic areas. Although there are several bone indicators to estimate the age of adult individuals, these changes are subject to habits and environmental conditions, unique to each subject, in such a way that antemortem changes are highly variable between individuals. Furthermore, given the nature of bone tissue, they are highly susceptible to postmortem deterioration processes; however, dental tissue is much more resistant to these deterioration processes and also presents changes associated with age, which continue once the individual reaches maturity; among the factors studied is the transparency of the root dentin (2).

Gustafson in 1950 presented the first scientific technique for estimating age in adults. It was based on longitudinal sections of teeth cut through the central zone. The technique consisted of assigning scores from 0 to 3 for the presence and number of age-related changes, such as attrition, periodontal ligament retractions, secondary dentin formations, root translucency, and root resorption. Scores were aggregated and a regression analysis with age was performed (3).

The methods developed can be subdivided into morphological/histological systems and biochemical/radiographic techniques. Gross investigations can be performed on sectioned or non-sectioned teeth and are based on regressive changes to which teeth are subject over time. These studies are used primarily to estimate the age of adult subjects and are partially influenced by functional and pathological processes resulting in considerable variability in both the intensity and rate of these changes: this results in estimates of adulthood less accurate with respect to techniques that use developmental stages (4).

Several methods have been used to assess apical translucency and its relationship with age. Among the traditional methods for estimating age in adults, the morpho histological parameters suggested by

Gustafson continue to find widespread use. Of the variables suggested by Gustafson, dentinal translucency is perhaps the easiest to assess and also relatively accurate in predicting age (5).

Root dentin becomes translucent at the apex around age 30. This phenomenon was first described by Bradford and was further investigated by other authors, such as Miller (micro radiographic studies) and Schroff (electron microscopic studies). Regarding the differences in dentin translucency by sex, some authors maintain that it has little significance. Prince and Ubelaker, however, considered it necessary to create two different formulas for the two sexes in order to calculate age using the two variables of dentin translucency and clinical attachment loss (4).

The translucency of root dentin has been studied and used in different investigations as a reliable indicator to estimate dental age since its incorporation by Gustafson (6).

Lamendin, *et al.* (1992) formulated a new method based on the analysis of root translucency and gingival recession. The Lamendin method has received considerable attention in forensic science because its application does not require special facilities, experience in biochemistry laboratories, dental preparation, or special training (7), the method is fast, easy to learn and use (8). The technique developed was applied to teeth with a single root and consists of the analysis of two dental variables (periodontosis and transparency) and three height measurements (periodontosis, transparency and root), applying a multiple regression analysis from the measurement of dental variables and using the Mann-Whitney U test for the comparison of means, developed the following formula:  $A \text{ (age)} = (P \times 0.18) + (T \times 0.42) + 25.53$ . Where,  $P = (\text{height of periodontosis} \times 100) / \text{root height}$ ; and  $T = (\text{transparency height} \times 100) / \text{root height}$ . This method is a good option to use in forensic cases (9). This investigation was carried out on a sample of 306 teeth, of known age, sex and race, the measurements were taken in millimeters and on the labial surface, since on this surface T is usually higher and where P is less susceptible to be influenced by pathological factors such as infections; periodontosis was defined as the maximum distance between the cemento-enamel junction and the soft tissue insertion line; Dentin transparency was defined as a physiological characteristic that never appears before the age of 20 and is due to the deposition of hydroxyapatite crystals within the dentin tubules, the measurement was taken from the root apex to its root. greater extension on the labial surface; Root length was defined as the distance between the root apex and the cemento-enamel junction. It was found that the mean error between the real and the estimated age was  $\pm 10$  years in the work sample, the upper incisors showed better precision than the other single-rooted teeth and the precision was not related to sex (10).

Subsequent studies focused on evaluating the performance of Lamendin's proposal in different populations (11-18). An interesting study was carried out in the Terry collection on 400 dental pieces of 359 adult individuals (166 women and 193 men between 25 and 99 years old) where it was concluded that periodontal recession cannot be used as a univariate age indicator. , due to its low correlation with chronological age, unlike apical translucency that showed a high correlation with chronological age, being an important indicator of age (12). Other investigations also confirm the relevance of dentin translucency as an indicator of age in the Lamendin method. (19)

The applicability of a Bayesian model using an international dental database (Forensic International Dental Database), including the height of the translucency of the root and the height of periodontosis as a method to estimate age in adults, both indicators combined are became a generalizable model for age estimation in adult cadavers, offering optimal results in any human population (20).

Gretel González Colmenares (2007) proposed a single formula for the mestizo population from Colombia, given the non-existence of a specific formula for this population group, following the modifications of Prince and Ubelaker (2002), eliminating sex as a discriminating factor, made a multiple regression, establishing the following equation:  $A = 0.87 \times RH + 0.18 \times P + 0.47 \times T + 11.22$ , Where, A = age in years, RH = root height, P = height of periodontosis  $\times 100 /$  height of the root and T = height of the transparency  $\times 100 /$  height of the root; This research was carried out taking 78 teeth, which were extracted from 71 male and 7 female cadavers, Colombian mestizos, with a known age, ranging from 25 to 87 years, admitted for autopsy to the Colombian Institute of Legal Medicine, incisors were taken and

upper and lower premolars, since they showed greater precision, the measurements were expressed in millimeters; for the height of the periodontosis, the maximum distance from the cemento-enamel limit to the level of the bone crest was measured; for the total height of the root, it was measured from the cemento-enamel limit to the root apex. These measurements were taken on the vestibular surface of the tooth, without sectioning it; The height of the transparency was measured from the root apex of the tooth, over the vestibular and distal surface, taking the highest extension of the two, varying the original technique of Lamendin, *et al.*, where it was measured only by the vestibular surface. , the results obtained showed that the new formula proposed is more precise than that of Lamendin, *et al.* For the Colombian mestizo population, the formula of Lamendin, *et al.*, increased the error of the estimate for the extremes of age of the population (15).

A study similar to the one we propose in this research was carried out comparing the González-Colmenares and Lamendin formulas with the Mexican population in fifty corpses, finding that the González-Colmenares method offers a small margin of error, but more frequently . Lamendin, for its part, has a greater margin of error, but in a very small number of times, which makes it more precise (21).

This study compares two methods considering the equations proposed by Lamendin, *et al.* and González Colmenares, through the investigation of one hundred fifty-three (153) single-rooted teeth extracted from cadavers initially in unidentified condition, which were later identified through the methods typified in article 251 of Colombian law 906 of 2004, such as dactyloscopy, genetics and dentistry. The following research problem is posed: Which of the two methods to estimate age in adults (Lamendin, *et al.* or González-Colmenares) presents the best correlation with real age in a Colombian sample of 153 single-rooted teeth from the cities of Medellín and Bogotá?

Colombia presents a high number of victims of forced disappearance, 80,674 between the years 1958 and 2021, according to the Observatory of Memory and Conflict (22); a corpse in an unidentified condition constitutes a potential missing person, so the estimation of an age range is an essential factor to guide its identification, as well as to carry out technical cross-checks between unidentified corpses and people disappeared, determining which of the two methods (Lamendin, *et al.* or González-Colmenares) is the most accurate to apply in the cities of Medellín and Bogotá is very useful in the Search for Disappeared Persons, taking into account that these cities represent a high percentage of the autopsies that are carried out throughout the country.

## **MATERIALS AND METHODS**

One hundred fifty-three (153) healthy single-rooted teeth were analyzed, these were extracted from one hundred fifty-three (153) unidentified cadavers, necropsied in the cities of Bogotá and Medellín (Colombia); who, after their identification, were in an age range between 22 and 93 years, with a mean of 46.26 years and a standard deviation of 17.55; 15 of them were females and 138 were males. The corpses corresponding to foreign citizens were not considered for the sample because the aim was to analyze the precision of the two methods for the Colombian population, nor were teeth affected by pathological processes such as caries or periodontal disease considered, since both methods they were validated in healthy teeth; The cases analyzed were admitted to the National Institute of Legal Medicine and Forensic Sciences between 2011 and 2019. For each tooth, three measurements in millimeters were taken with a Mitutoyo digital caliper: root translucency or transparency, understood as the length of the transparent area. -reference of root dentin from the buccal surface, extending from the apex, transmitting a lumen through the intact tooth, periodontal recession, distance between the cemento-enamel junction and the periodontal attachment level, and root length or height understood as the distance between the apex and the cemento-enamel junction; All the measurements were made on healthy teeth, not sectioned. Once the measurements were obtained, the teeth were repositioned in their respective alveoli, after which

the equations proposed by Lamendin, *et al.*, and González-Colmenares were applied to estimate age.

The Mitutoyo brand digital calipers used to take the measurements complied with the preventive maintenance requirements established institutionally through the Instructions for Preventive Maintenance Service for Intermediate Technology and Electromechanical Equipment- Code DG-A-I-144. The measurements were taken by two (2) Forensic Odontologists, from Bogotá and Medellín respectively, the measurement was defined for each of the variables of Transparency (T), Root length (RH) and periodontal recession (P); A file was created for the data collection in Excel, where the number of the necropsy protocol, sex of the corpse, the result of the measurement for each of the variables, the result obtained in the two methods and the real age of the corpse after its identification.

An experimental, retrospective and in vitro investigation was carried out, applying the Student's t-test to evaluate the means between the two methods, using linear regression models to evaluate the correlations between real age and dentin translucency, real age and periodontal recession, the statistical relationship of each method by city and the integrated relationship by joining both cities for each method.

The coefficients of determination (R<sup>2</sup>), the multiple correlation coefficients and the intersection of the regression line with 95 % confidence (95 % CI) were calculated. Values of  $p < 0.05$  were considered significant. Statistical analysis of the data was performed using R and Excel software.

## RESULTS

The correlation between the dental age estimated through the equations proposed by Lamendin, *et al.* (10) and González-Colmenares (15) and the real age of the corpse after its identification was studied, to establish which of the two methods better predicts age in the Colombian population. Before applying the hypothesis test, it was necessary to test if the variances are the same or different, using the var.test function of the R software, we obtained that the P-value is 0.1073, greater than the 5 % significance level, it is You can conclude that the variances are similar.

Once the variances were similar, we proceeded to test whether there were differences between the two methods with the t test function, using a significance level of 5 %. From the previous test, a P-value of 0.6133 was obtained, therefore, it is concluded that there are no significant differences between the two methods. The error range obtained for the 153 cases analyzed with the equation proposed by Lamendin, *et al.* and by González-Colmenares, is shown in table 1.

TABLE 1  
Error range

Years	Number of cases, Lamendin	Number of cases, González Colmenares
≤ 5	63	70
6 -10	54	51
10 - 15	18	18
> 15	18	14

Figure 1 shows a scatter diagram showing the relationship between real age and dentin translucency, showing a trend from the lower left to the upper right, showing a positive relationship. No relationship was found between actual age and periodontal recession.

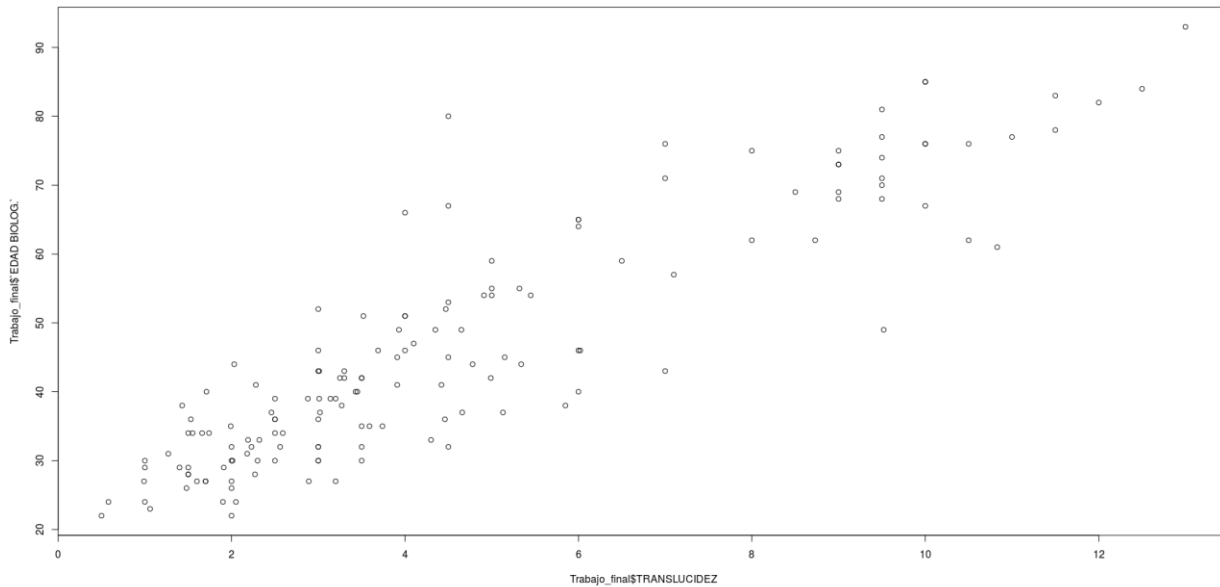


FIGURE 1

Scatter diagram showing the relationship between real age and dentin translucency

It was found that, for the sample from the city of Medellín, the relationship between Lamendin, *et al.* (10) and biological age is 84 %, with an intercept on the Y axis of 17.38 and a slope or inclination of the curve of 0.57. and a determination coefficient of 0.7135, where it can be seen that the equation explains the Lamendin variation by 71.35 % (Figure 2).

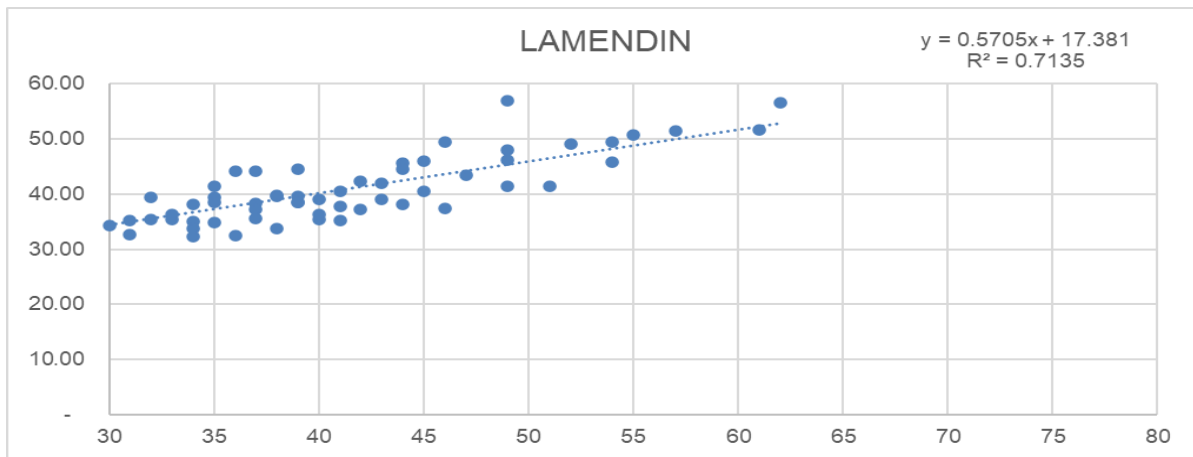


FIGURE 2

Relationship between Lamendin, *et al.* (10) and biological age in the city of Medellín

For the city of Bogotá, the relationship between biological age and that of the formula Lamendin, *et al.* (10) is 87 % with an intercept of 22.88 and a slope of 0.46, where the equation explains the variation of Lamendin, *et al.* (10) in 76.21 %. (Figure 3).

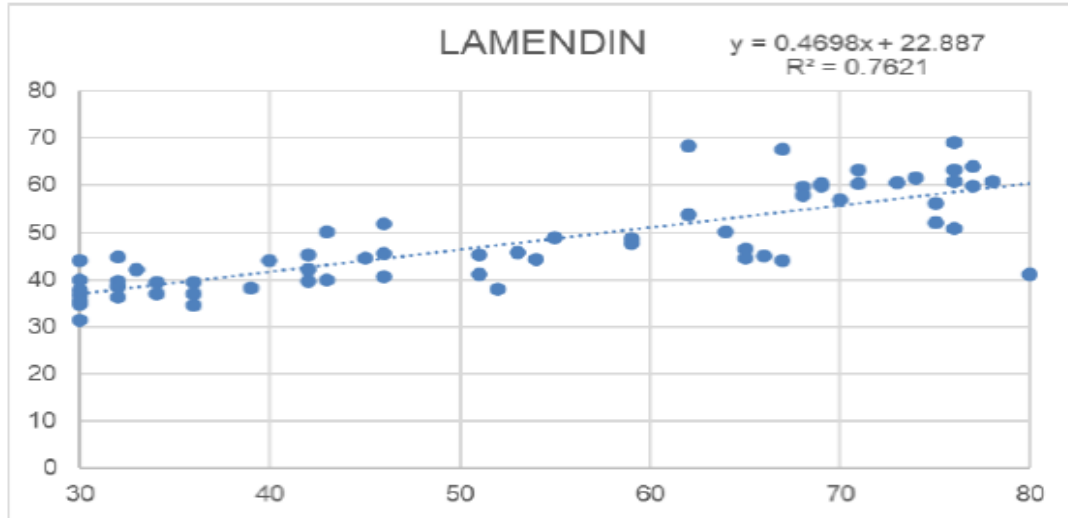


FIGURE 3  
Relationship between Lamendin, *et al.*, (10) and biological age in the city of Bogotá

It is important to consider that, when joining both populations corresponding to the city of Medellín and Bogotá, the relationship is 88 % with an intercept on the Y axis of 20.594 and a slope or inclination of the curve of 0.5027 and a coefficient of determination of 0.79, where it can be seen that the equation explains the variation of Lamendin, *et al.* (10) by 79 %. (Figure 4).

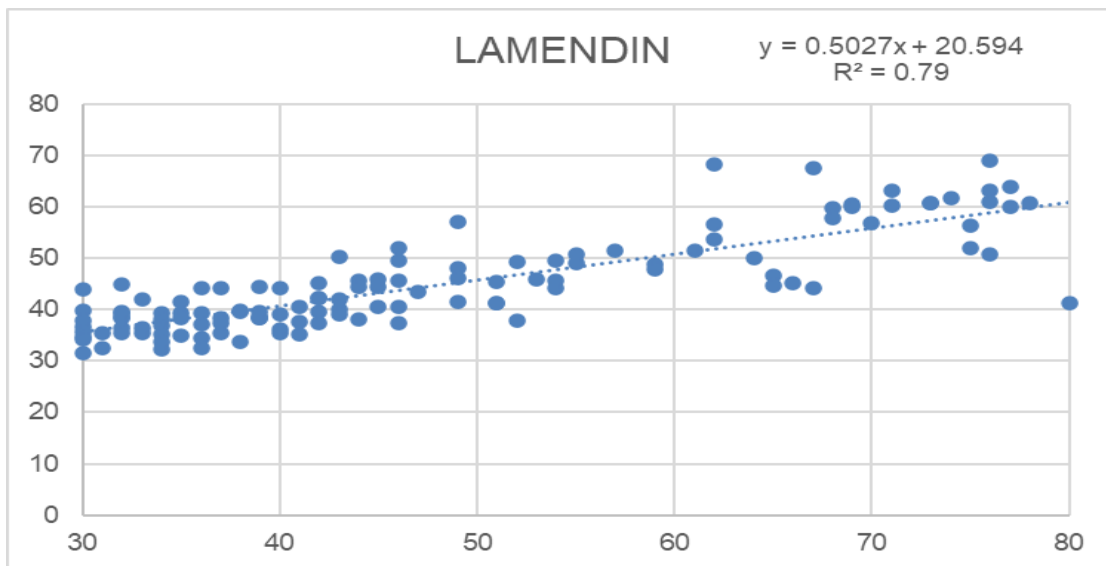


FIGURE 4  
Relationship between Lamendin, *et al.*, (10) and biological age in the cities of Medellín and Bogotá

When carrying out the calibration or adjustment process of the data in Excel, the intercept is close to zero and Beta or slope is equal to 1, which allows us to conclude that with the calibration, it is possible to achieve a more adjusted correlation between the biological age and the age determined by Lamendin, *et al.*, (10) adjusted or calibrated, reaching a relationship coefficient of 84 % for Lamendin, *et al.* (10) adjusted Medellín, 87 % for Bogotá and 88% with Lamendin, *et al.* (10) Calibrated by unifying both

populations, then, it can be established that for each additional year of biological age, Lamendin will increase age by one more year, which indicates an adequate correlation between biological age and age adjusted with Lamendin, *et al.* (10).

Regarding the application of the González-Colmenares formula (15), an 85 % relationship with biological age was found for the sample from the city of Medellín, with an intercept on the Y axis of 12.37 and a slope of inclination of the curve of 0.66 and a coefficient of determination of 0.7256, where it can be seen that the equation explains the variation of González-Colmenares (15), by 72.56 % (Figure 5).

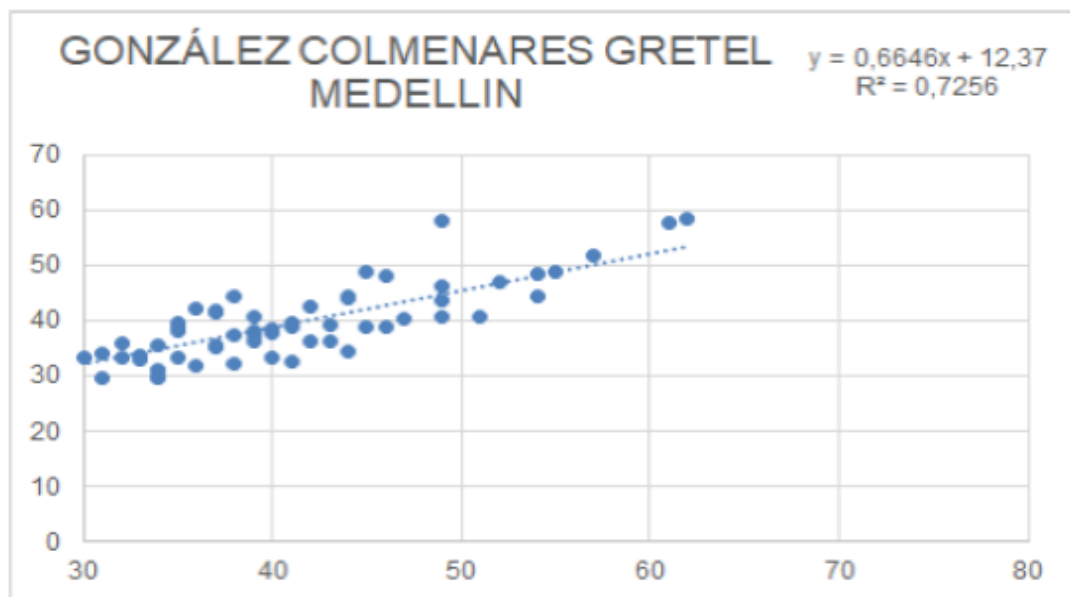


FIGURE 5

Relationship between González-Colmenares (15) and biological age in the city of Medellín

For the city of Bogotá, the relationship is 89 % with an intercept of 19.15 and a slope of 0.54, where the equation explains the variation of González-Colmenares (15) by 79.89 %. (Figure 6).



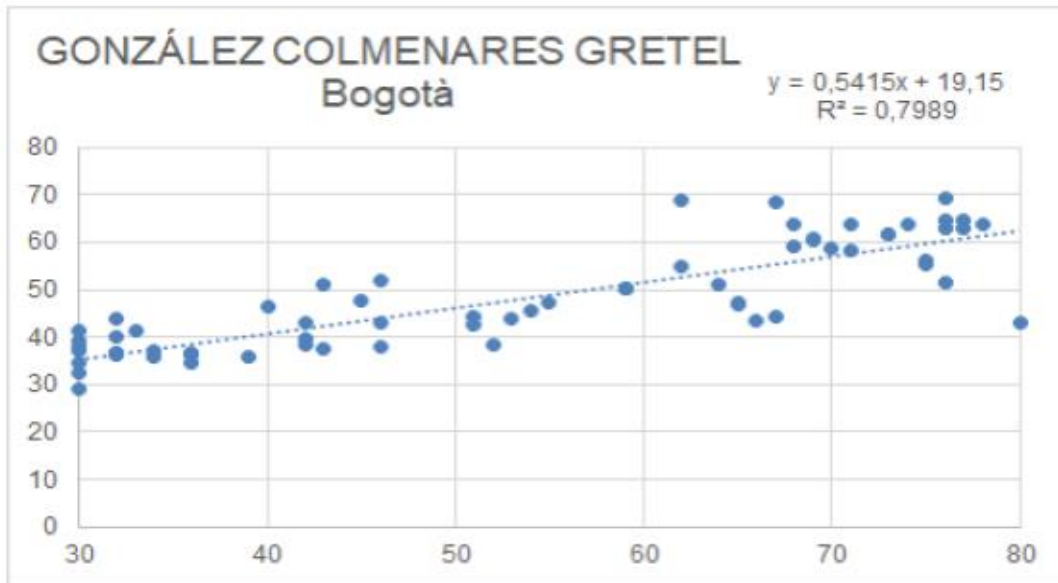


FIGURE 6

Relationship between González-Colmenares (15) and biological age in the city of Bogotá

By joining both populations of the cities of Medellín and Bogotá, the relationship is 90 % with an intercept on the Y axis of 16.29 and a slope or inclination of the curve of 0.5823 and a coefficient of determination of 0.8156, where It can be seen that the equation explains the variation of González Colmenares (15) by 81 %. (Figure 7)

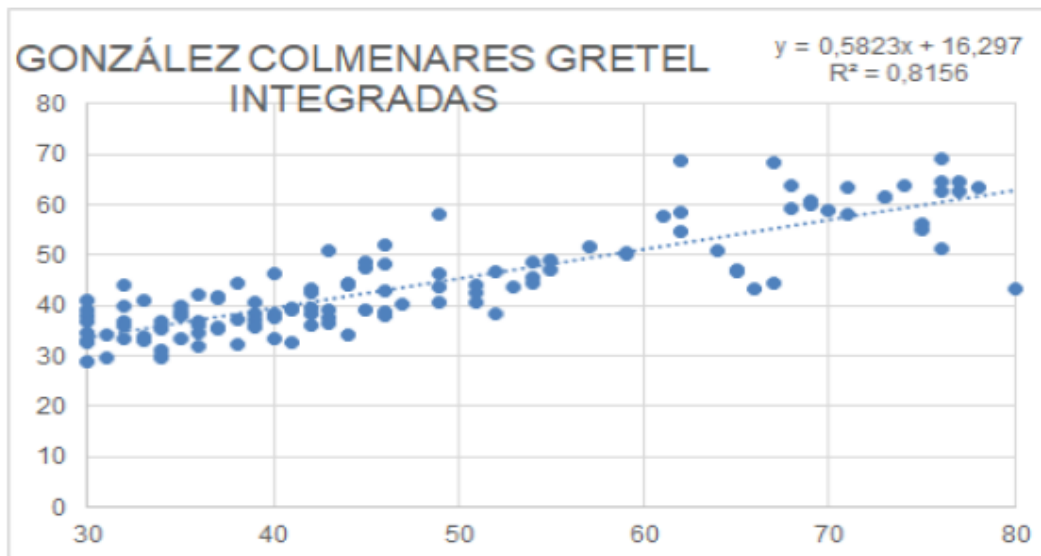


FIGURE 7

Relationship between González-Colmenares (15) and biological age in the cities of Medellín and Bogotá

When carrying out the data calibration process, the intercept is close to zero and Beta or slope is equal to 1, which allows us to conclude that when carrying out the calibration or adjustment of the data in Excel, it is possible to achieve that the correlation be more adjusted between the biological age and the age determined by González-Colmenares (15) adjusted or calibrated, managing to obtain a correlation coefficient of 85 % for Medellín, 0.89 % for the city of Bogotá and when integrating both capital cities, the correlation coefficient increases to 90 %, indicating that for each additional year of biological age, González-Colmenares will increase the age obtained by one more year.

## **DISCUSSION**

As reported in most studies, root transparency was found to be the most accurate measure within the parameters cited by Gustafson (wear, secondary dentin, cement apposition, root resorption, and gingival retraction); consequently, there is an increase in root translucency as age advances, this physiological marker of aging is very rarely influenced by internal and external factors, however it could be attacked by bacterial agents that produce a similar appearance of translucency (23).

On the other hand, although this research did not find a positive relationship between real age and periodontal recession, some studies have reported a positive correlation. Unlike translucency, this variable is more influenced by internal and external factors that could affect the precision of the method (23), so it is not recommended as a univariate variable in age estimation methods; some authors argue that periodontal disease tends to be related to age, Parra, *et al.*, found an important coefficient of determination for this variable  $R^2$  0.59, contributing to a better performance of the methods derived from the Lamendin technique (20).

The Lamendin, *et al.* (1992) method was carried out with the French population, while the González-Colmenares method was developed specifically for the Colombian mestizo population. The first method is reported in research as the most widely used and well-known worldwide, so it was necessary to know which of the two showed a better correlation with the real age of the corpse, in order to offer more precise age ranges, which allow guiding human identification and the search for Missing Persons. In Colombia.

## **CONCLUSIONS**

This study demonstrated the usefulness of the dental methods of Lamendin, *et al.* (10) and González-Colmenares (15) to estimate the age of unidentified adult corpses; no statistically significant differences were found in the application of both methods in the cities of Bogotá and Medellín. A positive relationship was found between root transparency and real age, but the same was not the case between periodontal recession and real age.

The correlation between the biological age and the estimated one is slightly tighter with the González-Colmenares method (2 %) than with the Lamendin method. For each more year of biological age that an individual has, González-Colmenares and Lamendin, *et al.* will increase one more year, if the formula is adjusted or the data is calibrated.

## **RECOMMENDATIONS**

More studies are recommended to observe the precision of both methods in periodontally compromised teeth and/or with pathological processes such as caries. It is also necessary to observe the precision of both methods in specific ethnic groups of the Colombian population.

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