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Effect of Gender, Ethnicity and Age of Patient on Size of Teeth and Overall Health of Teeth: An Analysis of Panoramic X-rays

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ABSTRACT

The objective of this study was to measure and evaluate the size of human teeth among 22 subjects of different age groups, gender and ethnicity. Additionally, the effect of age, gender and ethnicity on the type of dental procedure was investigated. The study was performed by analyzing the panoramic X-Rays of each subject, which were provided by Dr. J. Timothy Doerner. The statistical analysis was completed by using JMP 12 analytical data statistics software. In the study, we found that gender affects the size of teeth and the number and type of dental procedure done. Likewise, there was a significant difference in the ethnicity of patients and the number of dental procedures performed. Lastly, patient age also influenced the amount of dental procedures and type of dental procedures in patients.

INTRODUCTION

Teeth, which evolved around 230 million years ago, are an essential part of the human body (Eronen and Jernvale, 2008). They are not only important because of their function that is food processing, but they also contribute to overall health, speech and appearance.

We, as humans, have two sets of teeth, which start to develop as early as the 6th week in the uterus. Deciduous (baby) teeth usually begin to erupt around the age of 6 months and there are 20 baby teeth in total. Permanent teeth start to appear around the age of 6 years and by about age 13 there are 32 of them (Cate, 1998). Adults have four types of teeth: incisors, canines, premolars, and molars. Wisdom teeth are third molars (Ungar, 2010). They usually erupt around 17-25 years of age; however, sometimes they do not erupt at all. Factors influencing whether wisdom teeth will be impacted or not are diet, genetics and space in the mouth (Juodzbalys and Daugela, 2013). The difference between the deciduous and permanent teeth is the absence of the first and the second premolars and the third molars in the primary teeth. Each tooth has its own function and therefore they have different shapes. Incisors are chisel-shaped and they cut food. Canines are pointed and sharp and serve in tearing food. While premolars and molars have large biting surface and their function is to crush and grind food (Ungar, 2010).

Teeth consist of two parts: the crown and the root. The crown is the visible section of the tooth that appears above the gum line in healthy people that do not suffer from a gum disease. The root descends below the gum line and anchors the tooth to the alveolar bone (Clemente, 1987). The upper jaw is called maxilla, while the lower jaw is called mandible (Marieb and Hoehn, 2007).

The human tooth is made from four types of dental tissue: enamel, cementum, dentin, and pulp. Enamel is the hardest substance in our body and the outermost layer of the tooth that covers the crown. Enamel is transparent and mostly comprised of hydroxylapatite, a crystalline form of calcium phosphate (Ungar, 2010). Other components include water and organic compounds. The abundance of enamel varies over the surface of the tooth. It was found that the cusps are where the enamel is the thickest, up to 2.5 mm (Cate, 1998). The main role of enamel is to protect teeth against cavities.

Cementum is the specialized bone tissue that covers the root of the tooth. It is also composed of the mineral hydroxylapatite but in a smaller amount than in enamel. However, cementum is additionally comprised of collagen that is not present in enamel. The function of cementum is mainly to provide an attachment point for periodontal ligaments that connect the tooth to the alveolar bone.

Dentin underlies enamel in the crown and cementum in the root. It is produced by odontoblasts cells located in the pulp. Dentin is composed mainly of inorganic substances and, because of its soft and porous structure, is more likely to decay. However, dentin serves as a support for the crown and protection for the dental pulp.

The pulp is a soft connective tissue that is located in the center of the tooth under dentin (Ungar, 2010). It contains various types of cells such as: macrophages, fibroblasts, T-lymphocytes, preodontoblasts and odontoblasts that secrete dentin. The pulp contains blood vessels and nerves and, therefore, it also plays a role in the transport of nutrients (Walton and Mahmoud, 2002).

There are many dental conditions and abnormalities. Hyperdontia is a genetic disorder causing a formation of an additional tooth in the mouth. Usually it is one more molar such as, second or third molar. The opposite is a hypodontia causing some of the teeth to not erupt (Kokten et al. 2003).

Dental abnormalities are not the only causes that can affect the quality of life. If one or more teeth were missing it can lead to jawbone loss, which could cause facial pain, headache, collapsed face and wrinkles.

Root shortening and the wearing off of enamel are the primary causes of extraction and the loss of teeth. Root shortening is usually caused by infection of the gums and bones, or systemic diseases, such as diabetes, which makes it difficult to control the sugar level. Bruxism, or the grinding of the teeth, wears out teeth and cracks down the enamel, allowing oral bacteria to attach to the tooth's surface (Khan et al., 1998). Then, the bacteria form a plaque and break down the enamel causing various infections and cavities (West and Joiner, 2014). The presence of *Streptococcus mutans* and *Lactobacillus* spp. of bacteria is the main cause of dental caries (Kawari et al. 2016). However, mouth bacteria can be also beneficial. The most common bacteria living in an oral cavity are *Streptococcus mitis* and *S. oralis*. They compete with harmful bacteria and keep the oral micro flora in balance (Marsh, 2000).

There are four most common dental treatments that help restore dental health: fillings, root canals, dental crowns, and bridges. Dental fillings restore and cover the missing tooth structure caused by cavities or some physical trauma. The most commonly used material is tooth-colored composite resin, which is not as durable as porcelain. Root canal therapy is performed to remove damaged and infected tooth pulp, which when left

untreated can form an abscess (Cohen, 2006). Dental crowns are placed to protect a tooth damaged by cavity or broken by accident. The dental cap entirely covers the crown of the tooth and it is usually made of porcelain. Lastly, bridges are dental restorations that are used to replace one or several missing teeth. They can be removable or fixed, with fixed being most commonly used. They consist of a full artificial tooth with crowns attached from either side.

Tooth size and time of eruption varies among the individual teeth in the mouth and also among the genders. Males usually have longer canines than females. The length of male canines is on average around 25.5 mm (Garn et al. 1967). Interestingly, wisdom teeth on the lower jaw erupt 3-6 months later in females than males (Juodzbalys et al. 2013). Also, there are large racial differences in tooth size. Hanihara et al. (2005) found that Australians have the largest teeth while Western Europeans have small teeth and East/Southeast Asians have intermediate sized teeth. Other researchers stated that wisdom tooth eruption also varies among different races. In Nigerians, third molars can erupt as early as 14 years of age, while in Europeans as late as 26 years (Juodzbalys et al. 2013). The size, abnormalities, time of eruption and shape of teeth can all be affected by genetic, environmental and nutritional factors (Garn et al. 1965).

The present study was conducted in order to determine whether the size of teeth and the number and type of dental treatments performed were different based on the age, gender or ethnicity of patients. We examined 22 dental X-Rays that were provided by Dr. J. Timothy Doerner. The overall length of each tooth and the length of each crown of the tooth were measured using dental software available in the dental office. All essential information needed for the study was recorded and gathered data was analyzed by using JMP 12 Statistic Software.

METHODS

Materials

Dentists use numbering notations in order to correctly identify teeth. There are three most common numbering systems: the Palmer Notation System, which is mainly used by orthodontists, the World Dental Federation Notation System (FDI) used in Europe and the Universal Numbering System. The Universal Numbering System is mostly used in the USA (Nelson, 2014) and was used in this study (Fig. 1).

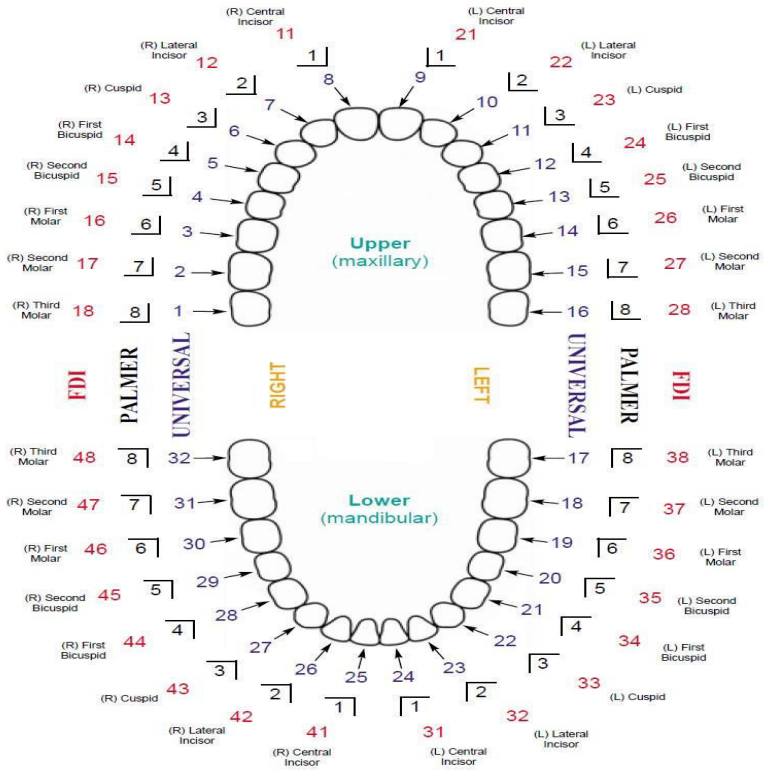


Figure 1: Three types of tooth numbering systems. The Universal numbering system was used to refer to teeth in this research. The image was retrieved from DentaGama (2015).

Subjects

A total of 22 patients from the dental office of Dr. J. Timothy Doerner were selected for this study. The study sample consisted of an unequal number of females and males (n = 22; 6 females, 16 males) with ages ranging from 15-59 years. There was not any requirement for the ethnicity of a patient; however, the goal was to have as diverse group of subjects as possible. Unfortunately, X-rays were only available for a limited time; therefore, the sample included only 3 Asians, 3 Indians, 7 Hispanics and 9 Caucasians. Confidential information of patients such as name and address were not recorded and were not disclosed by dental personnel. IRB approval is not required for studies based on anonymous retrospective chart reviews.

Analysis of X-rays and Teeth measurements

A panoramic dental X-Ray scan of both the upper jaw (maxilla) and lower jaws (mandible) was performed on each patient. This allows dentists to get a two-dimensional view of the jaw in one image and provides information about cavities, development of wisdom teeth, jaw problems and many other dental issues. It uses a low level of radiation and it is found in every dental office (White and Pharoah, 2014). In our study, we analyzed the X-Rays with the help of videos and articles on how to read dental X-Rays that are available on Google. The exclusion criteria were any blurred X-ray scans and X-rays on which patients turned their head causing the increased magnification of teeth on the side opposite to the film. For illustrations of X-Rays with different dental treatments performed see Fig. 2 and 3.

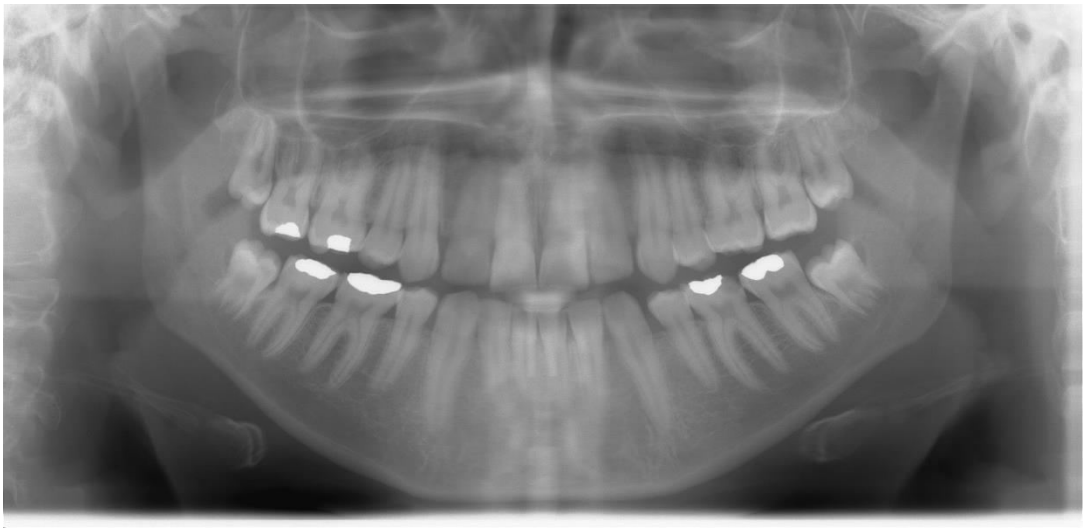


Figure 2: Example of the panoramic X-ray analyzed in the research. This patient is not included in the measurements. This figure serves only as an illustration of fillings that are present in tooth 2, 3, 31, 30, 18 and 19. All of these teeth are first and second molars.

Figure 3: X-Ray illustrating bridges and root canals on the upper jaw and one filling in the lower jaw. This patient was not included in our study.

A panoramic X-ray of each patient was analyzed and the age, gender, and ethnicity of the patient were recorded in a Microsoft Excel spreadsheet. Two measurements of a tooth, the total length of a tooth (Fig. 4) and the crown length (Fig. 5 and Fig. 6), were digitally measured in millimeters using Schick Dental X-Ray Software provided in the dental office. We measured the crown length from the highest cusp of the crown to the neck of the tooth. Similarly, we measured overall length of the tooth from the highest cusp of the tooth to the root apex. A calibration tool built in Schick Dental X-Ray Software was used to convert all measurements to millimeters. Lastly, the absence and presence of the tooth and the type of treatment performed on the tooth was noted in the table for the further evaluation.

Figure 4: Measurement of the whole tooth length using Schick Dental X-Ray Software. This measurement was not recorded because it was not taken properly since the root measured was curved. Note that patient is missing all wisdom teeth (third molars).

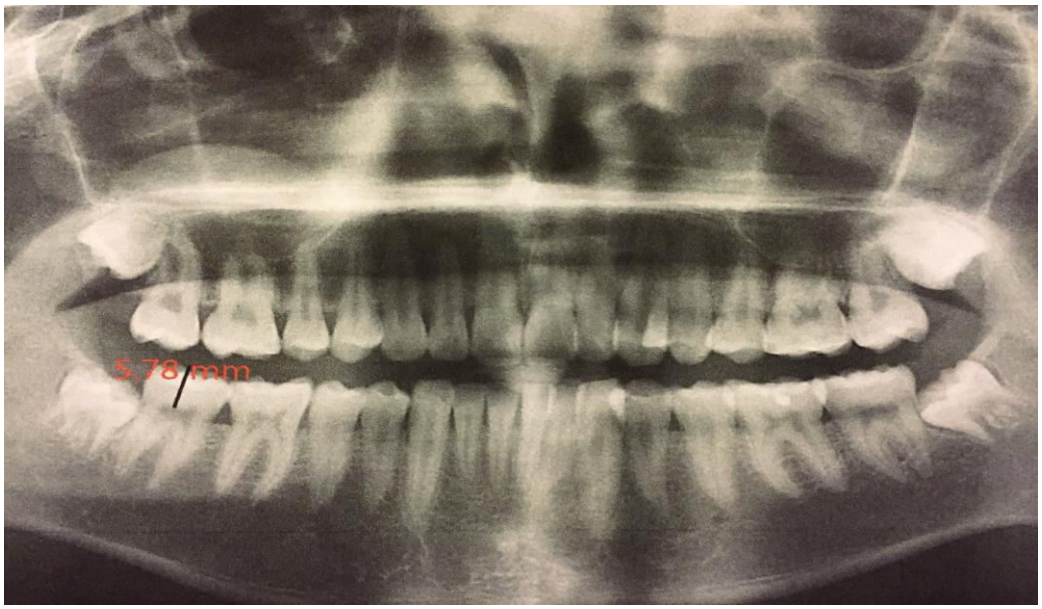


Figure 5: Measurement of crown length using Schick Dental X-Ray Software. Note that all wisdom teeth are impacted.

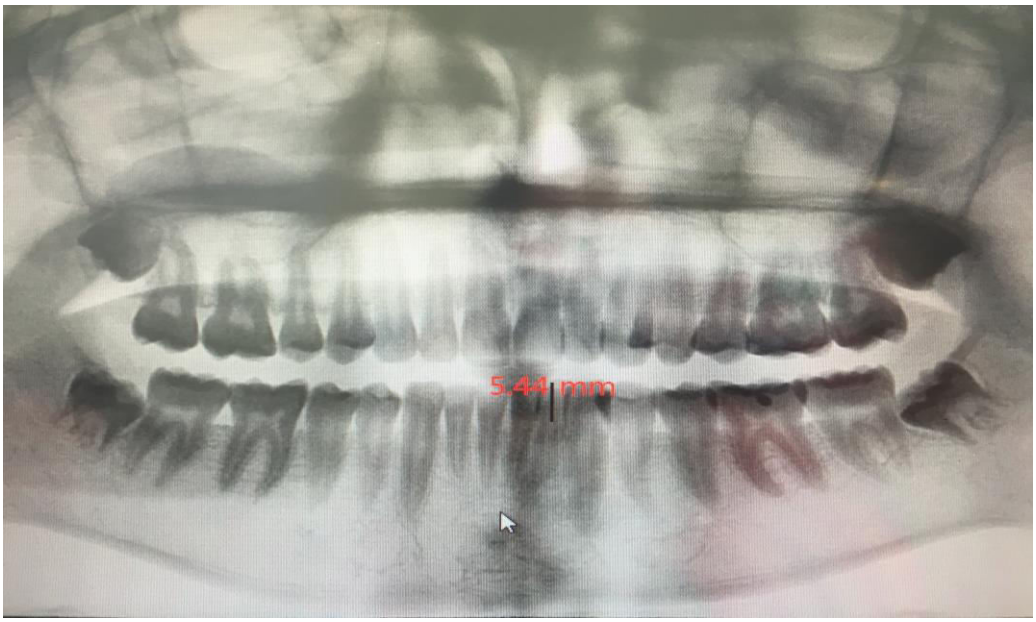


Figure 6: Measurement of tooth crown length using Schick Dental X-Ray Software. On this X-Ray the contrast is changed in order to see teeth better.

Statistical Analysis

The statistical analyses and calculations were carried out using JMP 12 statistical software. We performed several types of statistical tests such as regression, t-test, ANOVA and Pearson's chi square test. Types of tests were performed as follows:

- Age vs. Total Length of Tooth- regression test
- Age vs. Crown Length- regression test
- Age vs. treatment Present Y/N- t-test
- Age vs. Type of Treatment- ANOVA
- Gender vs. Total Length of Tooth- t-test

- Gender vs. Crown Length- t-test
- Gender vs. Treatment Present Y/N- Pearson's chi-square test
- Gender vs. Type of Treatment- Pearson's chi-square test
- Race vs. Total Length of Tooth- ANOVA
- Race vs. Crown Length- ANOVA
- Race vs. Treatment Present Y/N- Pearson's chi-square test
- Race vs. Type of Treatment- Pearson's chi-square test

Below we represent the results of our study.

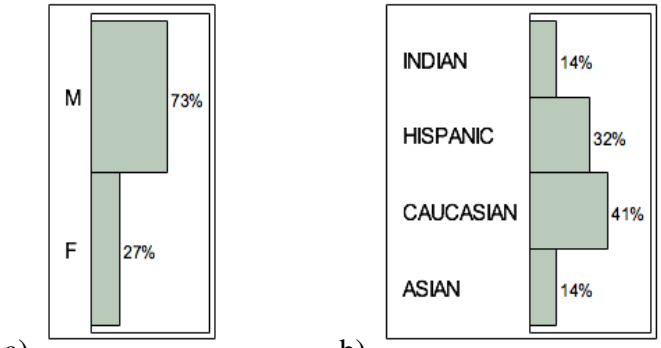
RESULTS

Table 1: The Explanation of Abbreviations.

Present Y	Tooth present
Present N	Tooth not present
Present ND	Tooth present but not developed
Treatment F	Filling present
Treatment RC	Root canal present
Treatment C	Crown present
Treatment C, RC	Crown and root canal present
Treatment B	Bridge present
F	Female
M	Male

Statistical Analysis of General Information

The study contained 73% males and 27% of females (Fig. 7a). The sample population consisted of 41% Caucasians, 32% Hispanics, and 14% Indians and Asians (Fig. 7b). The average age of males was 35 years while that of females was 53 years (Fig. 8a and 8b).



a) b)

Figure 7: (a) Gender distributions. (b) Race distributions.

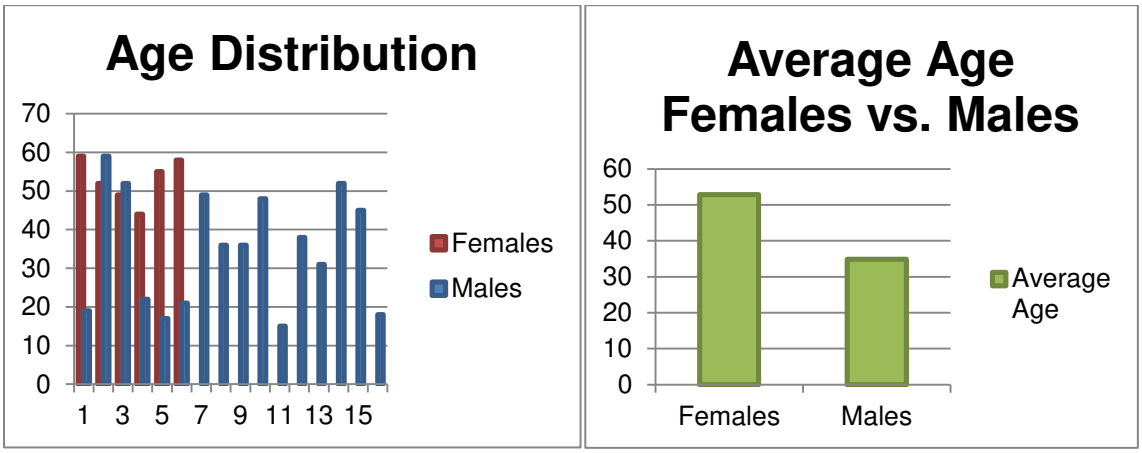
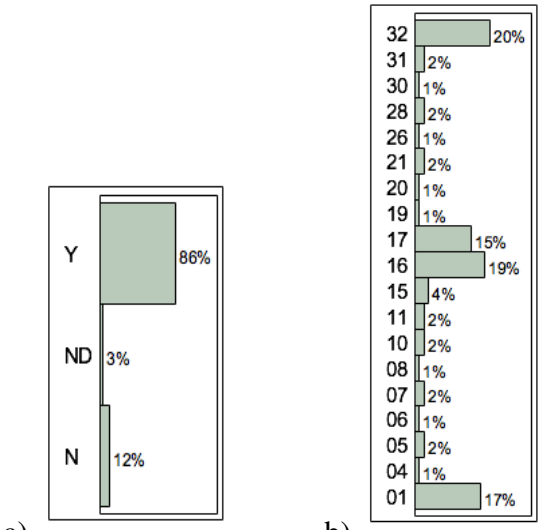


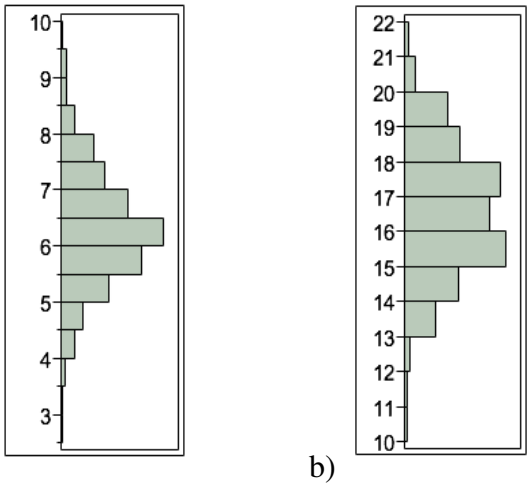
Figure 8: (a) Age distribution of male and female patients. (b) Average age distributed by gender.

Overall 86% of teeth were present in patients, other teeth were present but not completely developed and the rest were missing (Fig. 9a). Twenty percent of our population sample were missing tooth number 32, and 19% were missing tooth number 16, 17% were missing tooth number 1 and 15% were missing tooth number 17 (Fig. 9b). All these teeth are wisdom teeth.



a) b)

Figure 9: (a) The percentage of teeth present, not present and not developed in the population sample. (b) Tooth number of missing teeth distributed throughout the sample.

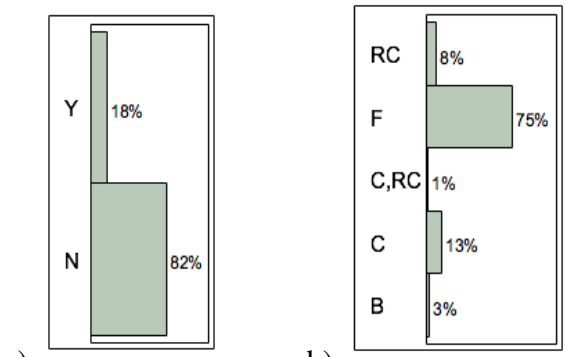


a) b)

Figure 10: (a) Crown length (mm) amongst the sample population (b) Whole tooth length (mm) amongst the sample population.

The average crown length was found to be 6.29 mm (Fig. 10a; range: 2.71 mm to 9.78 mm). The average tooth length was 16.58 mm (Fig. 10b; range: 10.24 mm to 21.44 mm).

Eighteen percent of our sample population had some dental work done, while 85% had teeth without any dental alternations (Fig. 11a). Seventy-five percent of this patient population had a regular filling procedure, 13% had crowns and 8% had root canals (Fig. 11b).



a) b)

Figure 11: (a) The presence and absence of dental treatments. (b) Type of dental treatment performed.

Effect of Gender

We found that males had significantly bigger teeth than females (Fig. 12a; t-Test: t Ratio = 5.17; $p < 0.0001$). Likewise, males had significantly larger crowns than females (Fig. 12b; t-Test: t Ratio = 3.452; $p > 0.0006$). There was a significant difference in the amount of overall dental procedures performed in females and males (Fig. 12c; Pearson:

$\chi^2 = 37.87$; $p < 0.0001$). Thirty-four percent of teeth from the female population had some type of dental procedures done, while only 12% of male teeth had dental alterations. Additionally, we found a significant difference between the gender of the patient and the type of dental procedure performed (Fig. 12d; Pearson: $\chi^2 = 23.17$; $p = 0.0001$). Males had more regular fillings (65%) than females (35%). However, female patients had significantly more of root canals (89%) than males (11%). Also, females had more crowns (86%) than males (14%).

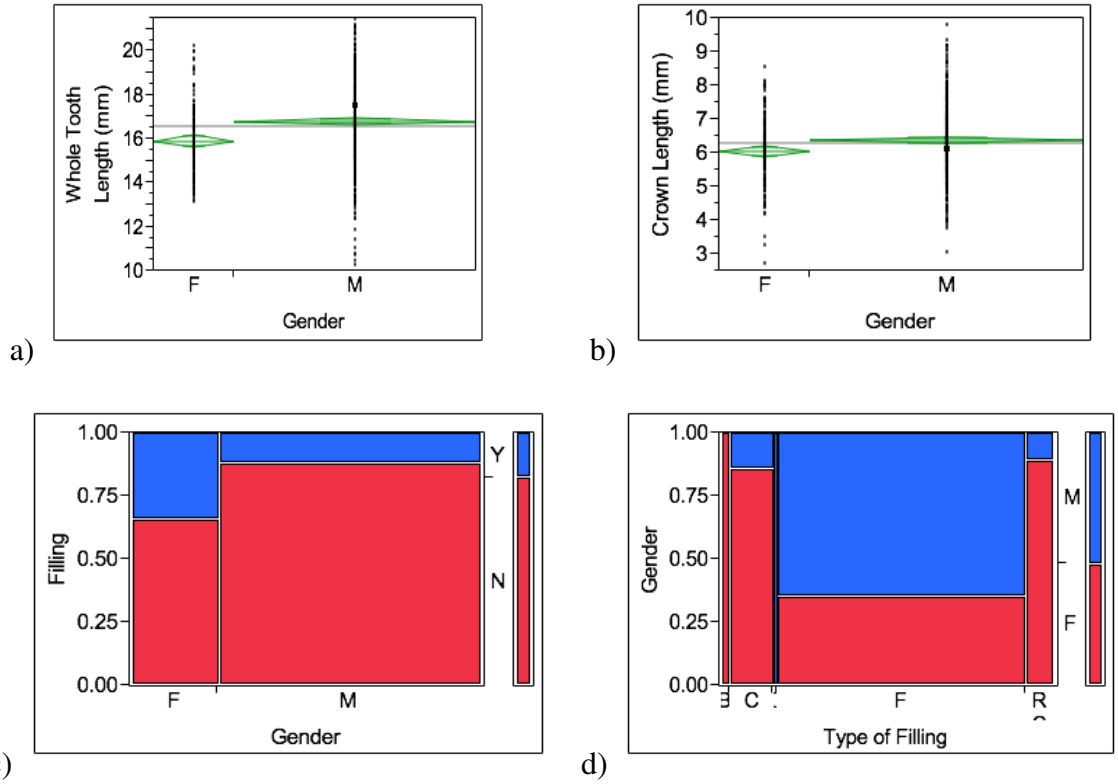


Figure 12: (a) Tooth length by gender. (b) Crown length by gender. (c) Absence/presence of dental treatment by gender. (d) Type of dental treatment performed by gender.

Effect of Ethnicity

There was no significant difference in the whole tooth length between races (Fig. 13a; ANOVA: F Ratio = 1.48; $p > 0.219$). Similarly, we did not find a significant difference between the race of the patient and the length of the crown (Fig. 13b; ANOVA: F Ratio = 1.43; $p > 0.234$). However, we found that race significantly affected the amount of dental procedures done (Fig. 13c; Pearson: $\chi^2 = 46.38$; $p < 0.0001$). Only 1% of the total teeth of the Asian patients had dental treatments, while 24% of the teeth of Caucasian patients and 25% of the teeth of Hispanic patients had some type of work. Statistically there was no significant difference between the race and the type of dental procedure done (Fig. 13d; Pearson: $\chi^2 = 8.91$; $p > 0.350$).

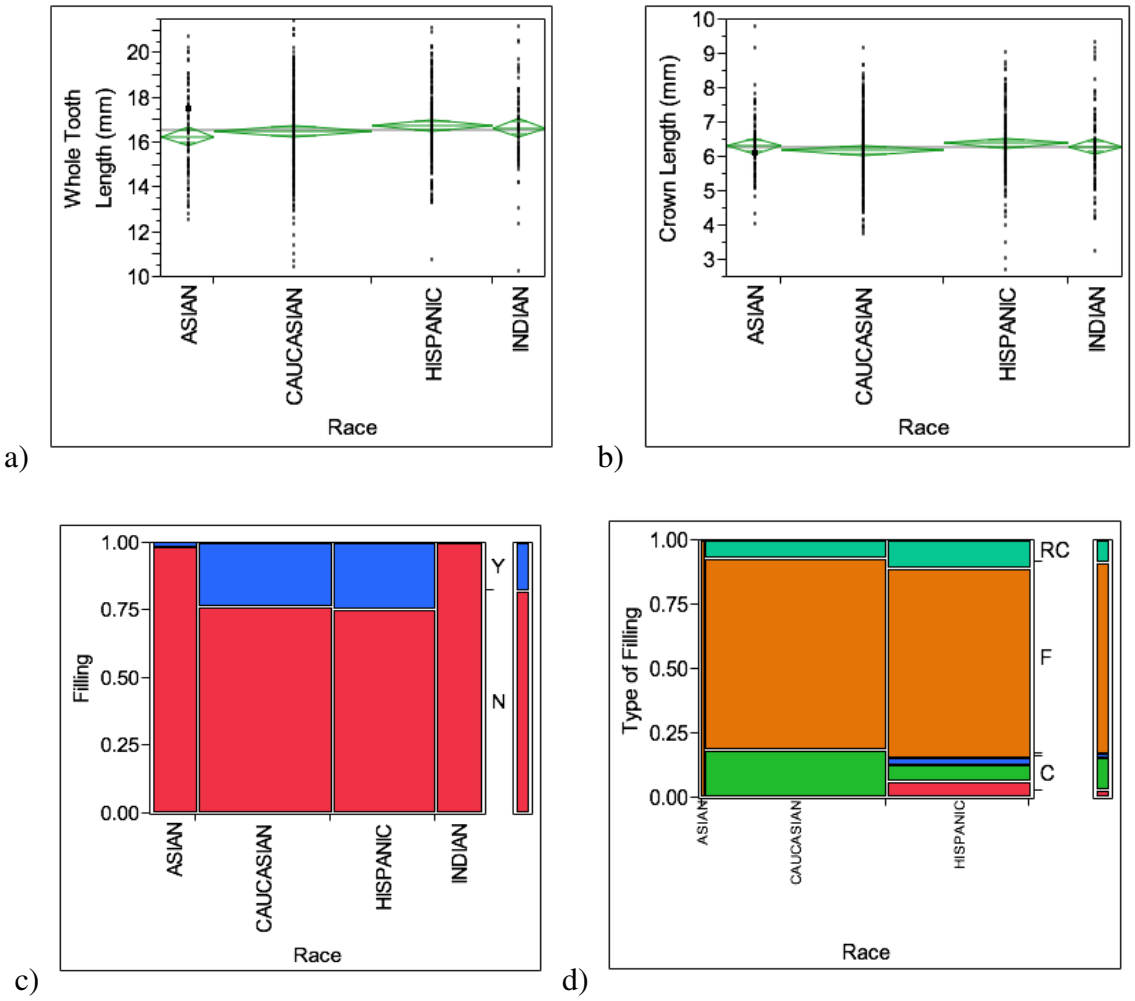


Figure 13: (a) Whole tooth length by race. (b) Crown length by race. (c) Presence/absence of dental treatment by race. (d) Type of dental treatment by race.

Effect of Age

Regression analysis revealed that there was no significant relationship between the whole tooth length and age of the patient (Fig. 14a; Regression: $R^2 = 0.0046$; $p > 0.096$). Likewise, there was not a significant correlation between the age of the patient and the crown length (Fig. 14b; Regression: $R^2 = 0.000752$; $p > 0.5006$). However, we

found a significant difference in age of patient based on the absence or presence of treatment (Fig. 14c; t-Test: t Ratio = 9.53; $p < 0.0001$). The average age of people with no dental work was 37 years, while the average age of people with dental work was 51 years. Also, there was a significant difference between the age of the patient based on the type of dental treatment performed (Fig. 14d; ANOVA: F Ratio = 9.11; $p < 0.0001$). Overall, people under 50 years old had mostly fillings, while crowns, root canals, and bridges were common in people over 50 years old.

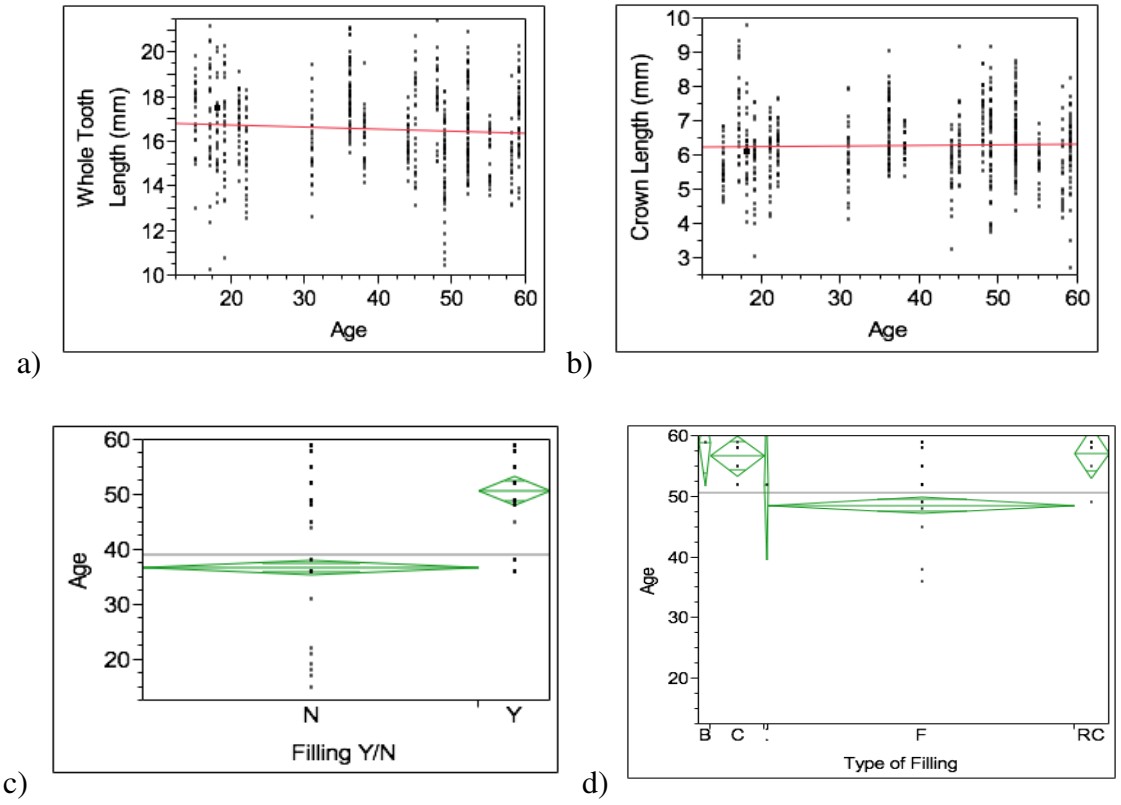


Figure 14: (a) Whole tooth length by age. (b) Crown length by age. (c) Presence/absence of dental treatment by age. (d) Type of dental procedure by age.

DISCUSSION

Generally speaking, most patients were missing wisdom teeth. This is expected because of the tendency for food to get stuck at the back teeth making it difficult to clean. Bacteria start to feed on the remnants of food; by consuming it they produce acid, which decomposes the enamel producing the cavity. Likewise, bacteria cause damage to bone, leading to loss of teeth (West et al. 2014). Most likely, the wisdom teeth of our sample population were extracted even before they started to cause issues. This is a very common procedure in the USA. Impacted third molars may cause a lot of issues such as swelling of the gums, crowding of the teeth and damage to the roots of second molars (Mettes et al. 2012). However, the removal of third molars, like every surgery, can cause complications such as nerve damage, infection and pain. If wisdom teeth are taken good care of they could be useful in older age for the attachment of bridges (Kim et al. 2015).

In the patient sample studied, the average tooth length was 16.58 mm (Fig. 10b; range: 10.24 mm to 21.44 mm), while the average crown length was 6.29 mm (Fig. 10a; range: 2.71 mm to 9.78 mm). These results seem not to be in accordance with previous studies. A study evaluating anatomic width/length ratios of unworn and worn maxillary teeth in white patients, found that crown lengths of central unworn incisors were 11.67 mm, while worn incisors were 10.67 mm long and premolar were 9.33 mm long. The study did not record any tooth crown shorter than 7.60 mm (Magne et al. 2003).

The most common dental procedure in our population were fillings. This result was expected because the average age of our sample was 44 years. Crown, root canals and bridges therapy were common in people over 50 years old.

Effect of Gender

In the patient sample studied, all four statistical tests performed were significant. A comparison between gender and the size of teeth revealed a dramatic difference. Males had bigger teeth than females; likewise they had bigger crowns than females. These observations are in accordance with the results of research stating that males have on average larger crowns than females in the human population. Studies suggest that sexual dimorphism is caused by the presence of more dentin in the crown of male teeth. Sex-linked genes affect the amount of both enamel and dentin in crowns of teeth (Schwartz and Dean, 2005). Additionally, we found that females in our sample had more dental procedures done than males. Even though females are thought to take better care of their teeth, females had more root canals and crowns. A study suggests that women have better oral hygiene and overall health; however, they still have fewer teeth and more cavities than men (McGrath and Bedi, 2000). In our study, the average age of females was 53 years while males averaged only 35 years of age. This likely explains why women in our study had more dental treatments than men. Meisel et al. (2008) found that socioeconomic status and the number of children born is associated with increased risk of tooth loss. Likewise, the lack of estrogen in postmenopausal women influences tooth loss (Meisel et al. 2008). Estrogen deficiency enhances osteoclast production, which plays an important role in bone homeostasis (Vaananen and Harkonen, 1996).

Effect of Ethnicity

Our research suggests that race affects the number of dental treatments in patients. We found that Asians and Indians had much healthier teeth than Caucasians and Hispanics. Previous studies have reported that Asian Americans have lower rates of edentulism (loss of teeth) than Caucasian, Hispanic, and Black patients (Wu et al. 2013). Likewise, Wu et al. (2013) suggests that it could be because of a diet low in fat and sugar and also of different family upbringing. However, mostly likely it is caused by both genes and environment. Other tests such as size of teeth and the type of treatment based on ethnicity were not significant. Insignificant results may be caused by our small sample size and unequal number of ethnicities.

Effect of Age

Age analysis indicates that as patients got older their teeth had more dental treatments. Similarly, as patients got older they had more root canals and crowns. In contrast, people under 50 years of age mostly had regular fillings. These findings support other studies arguing that dental caries and periodontal disease increase with age (West et al. 2014). However, we found no evidence of an effect of age on the crown length or overall tooth length.

Study Limitations

Our study had a few limitations. First, we did not have any experience with dental anatomy and analyzing dental X-Rays before our study. We only used information provided online. There was no help or guidance from dental professionals.

Second, the actual size of the tooth corresponding to the size of the tooth on X-ray, was likely not accurate. Studies suggest that panoramic radiograph is unreliable tool for measurement of teeth because it overestimates the size of teeth by 6.3 mm. The reason is that each manufacturer develops different rotational patterns, which then causes variability in patients jaw dimensions (Flores-Mir, 2014). In our study, it looks like the panoramic radiograph underestimated the size of teeth instead of overestimating. However, our comparisons are still valid because we used the same radiograph for all our samples and calibrated using the same method before every patient.

Third, we did not exclude worn teeth and young people with orthodontic treatment from our study. This could dramatically affect our results. Since the orthodontic treatment can shorten or elongate root apex depending on the age of patient (Mavragani et al. 2002). Mavragani et al. (2002) suggests that people who had the orthodontic treatment at a younger age might have longer roots than people having orthodontic treatment at a more advanced age.

Due to a small and not very diverse population sample, and novice examiners, further studies are needed to understand the impact of gender, ethnicity and age on the size of teeth and overall teeth health. Additionally, the method of measurement of teeth should be reconsidered in order to obtain accurate results.

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