Research Article

General Factors of Anatomical Variation on the Size and Number of Dental Roots Influencing the Choice of Immediate Implants

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Abstract
Bone metabolism is gaining more prominence due to osseointegrated implants. Even after a minimally traumatic tooth extraction, there are natural reductions and losses in the proportions of the alveolar bone and other periodontal tissues. Maintaining these dimensions has become a challenge for researchers. Immediate implants are set in the same surgical act as tooth extraction. Implants are recommended aiming at reducing the waiting time for bone repair and thus offering the necessary stimuli to the bone for its dimensional, functional, and esthetic maintenance. Planning prior to immediate setting should take into account anatomical variations and even anomalies mainly related to the dimensions and number of tooth roots. Among the general factors of anatomical variation, those related to Gender, Age, Biotype, and Ethnicity stand out. These data were provided in studies carried out by several authors in several countries, correlating them with the dimensions and number of tooth roots. A selection of works using measurement methods as Cone Beam Computed Tomography or direct measurements in extracted teeth was carried out. Studies confirm that Panoramic Radiography presents greater distortions and does not provide sharpness for dimensional boundary markings. Significant data were obtained and confirm the correlation of these general factors of anatomical variation with the length and number of tooth roots. Further studies need to be carried out, in order to provide clinicians with details of these variants, important in the planning and prior choice of the best shape and size of the dental implant to be installed.

Keywords: Immediate Implant, Dental Root Dimensions, Gender, Age, Biotype, and Ethnicity

Introduction

Man's quest to reposition parts of the human body dates back to Ancient Egypt, with records of "prostheses" and other artifacts. A great leap in this challenge was the discoveries made by Per-Ingvar Brånemark, (1965), who carried out experiments to investigate microcirculation, using titanium alloy chambers introduced into the bone marrow of rabbit tibia [1].

The concept of osseointegration was only presented at the Harvard conference in 1978. Today, its principles are followed around the world. Surgical principles for achieving osseointegration were questioned and investigated and a new classification of implants was proposed, leading each author to protect his own technique, making sure all protocols are followed adequately.

One of the first questions to the traditional guidelines was to reinforce the prerogative of installing the implants only after the complete repair of the alveolar bone, after a tooth extraction. However, this could take many months, whereas in the proposals for immediate implants, that is, performed at the same time as the dental extraction surgery, the number of surgical interventions is reduced, allowing greater preservation of soft tissues, as of the alveolar crest practically remains, thus showing better aesthetic results [2].

Currently, cone beam computed tomography is the radiographic technique of choice for imaging hard tissues in the oral cavity. This equipment shows anatomical structures and provides a three-dimensional image, demonstrating the exact location of a tooth included in three planes in space, without overlaps and distortions. Such images are observed in conventional modalities, such as panoramic images, at low doses of radiation compared to multiple detectors computed tomography (CT) scans [3].

What is desired with dental implant treatment is the aesthetic and functional success observed in the long term. As one of the priorities, customers' expectations must be met by extending the reconstructed area with prostheses supported by these implants. To achieve these goals, the experience, and knowledge of the clinician and the patient's risk factors, as systemic alterations, are added to the dimensional changes to be followed during the healing period after tooth extraction thus influencing the results, especially the aesthetic ones. It should be considered that after the implant is set, the resorption of the alveolar bone ridge generally results in loss of height of the buccal crest.

Another way of perceiving the risk and preventing the underlying resorption of hard tissues is to observe the discoloration of the mucosa, because of the excessive compression caused by the suture. Such discoloration foreshadows the failure of the procedure [4].

The aim of this review is to carry out an updated survey by searching for assessments regarding teeth sizes, especially their roots, as well as the main anatomical variations related to the age, ethnicity, and gender of the patients as well as some related structures in the specialized literature.

This review aims at assisting implant dentists in predicting the possible need to change the position of the implant to be set immediately after tooth extraction, thus avoiding resorption of the alveolar bone, among other complications.

Bone Metabolism and Care in Dental Extraction Prior to Implantation

The repair of the alveolar bone is initiated after tooth extraction, which will follow the regular stages as in any tissue repair process, even if extraction has been minimally traumatic. These stages of bone remodeling correspond to the phases of the internal and external alterations of the dental alveoli presenting dimensional reductions in the thickness of the alveolar ridge. Much of the bone resorption from dental alveoli should occur within a maximum of one year after extraction, as in the first three months, two-thirds of this resorption would have already occurred [5, 6].

One year after tooth extraction, the alveolar bone crest undergoes a horizontal reduction of the buccal-lingual of 5 up to 7 mm, with the greatest reduction observed in the first 3 months. At these sites, the reduction in the height of the alveolar ridge, also called vertical reduction, is around 2 to 4.5 mm after the first year of tooth extraction [7].

The consequences of a slightly more traumatic tooth extraction can result in resorption with a reduced height of the alveolar ridges including those of the neighboring teeth, consequently causing gingival retractions, with roots exposure. Such functional and aesthetic losses may be responsible for the implant failure, thus requiring the need to use restorative treatments, including surgical procedures with bone and periodontal grafts. Another organic reaction to trauma is the formation of fibrous tissue, which can prevent healing and tissue repair, as in natural bone regeneration [8, 9].

As part of the tissue repair process, a good blood supply to the bone alveolus in the first stage is much important so a formed clot plug can fill it. This blood supply originates from three sources as to know: the capillaries of the periodontal ligament, the capillaries of the periosteum, and the capillaries from the branches of the alveolar arteries that reach the endosteum. Thus, it is important that local anesthesia prior to dental surgery is technically correct avoiding the excessive use of vasoconstrictors since they can cause long-lasting ischemia, harmful to bone repair [10-12].

One of the characteristics of the bone closest to the periosteum and the endosteum is the presence of less circumferential lamellae tending to flat, thus conferring a coating aspect. The new bone deposition from the periosteum and endosteum is appositional. Appositional growth is observed by depositing a new matrix on a pre-existing bone surface, or on an implant. In this way, lining cells differentiate into osteoblasts with osteogenic activity, and new layers of cells producing the extracellular matrix are added to the underlying surface. Due to this appositional growth, the orientation of the tension lines also provides greater structural resistance allowing greater bone-implant contact, unlike what happens in osteoid production [5, 6].

Good dental implant planning must ensure this close contact, so that the implant does not present discrepancies between its

dimensions and the alveolar cavity's size after its setting. Thus, membranes, barriers, and grafts started to be used to obtain guided bone regeneration [12].

This direct structural and functional connection between the live bone and implant surface, called osseointegration, was certainly one of the most significant scientific discoveries in dentistry in the last 30 years [13].

A potential disadvantage with immediate implants may be the distance between the implant surface and the socket wall; therefore, gaps may be present after setting, since the dental roots do not have a regular circular diameter. It is also possible that one or more bone walls are partially reabsorbed due to illness or may have been damaged after tooth extraction procedures [14].

In order to achieve excellence when setting immediate implants, there are five main aspects to be considered during the decision-making stage thus helping to avoid errors that can lead to difficult aesthetic situations: (I) the presence of the buccal bone plate, (II) primary stability, (III) the design of the implant, (IV) the filling of the space between the bone and the implant and (V) the tissue biotype. [15, 16].

Tooth extraction must be atraumatic to avoid bone loss. When positioning the immediate implant in its ideal three-dimensional position, the gaps must always be filled with a biomaterial graft. It is recommended that the soft tissue contour be maintained through relief and compensation to obtain the buccal overlay of the soft tissues on the biomaterial or on some soft tissue graft interposed to fill and add volume to the gingival contour. When properly made and adapted, temporary crowns can suit as adjuvants in immediate implants to maintain soft tissue contours [15, 16].

Important anatomical variations related to the size of the roots.
As examples of some important anatomical variations in the mandible, the bifurcations of the mandibular canal, the positioning of the mental foramen, as well as the lingual foramen and its associated intraosseous channels can be highlighted. Preoperative examinations should also consider a greater concavity of the sublingual fossa, present in many of the patients, which can extend to the region of the second and first molars. Perforation of the lingual cortical plate in this area during implant preparation can result in injury of the lingual nerve or the adjacent sublingual and/or submental arteries [17].

The alveolar bone ridge develops depending on the appearance and maintenance status of the teeth, since the beginning of dental root formation. However, the size and shape of the alveolar process depend mainly on the direction of the tooth eruption, as well as on the individual size, shape, and position of each tooth and, secondarily, on the physiological and pathological stimuli of each tooth and its supporting structures, reflected in bone modeling and remodeling processes. From the clinical perspective, it seems relevant to assume that, in the area of aesthetic priority,

the facial alveolar bone wall should be, at least 2 mm wide, to avoid significant reabsorption of the buccal bone plate at the time of implant setting. If thickness is not adequate, bone augmentation procedures might be necessary and involves more invasive techniques, time, cost and risks, which the patient must be willing to accept in order to guarantee ideal aesthetic results [18].

Some important anatomical variations show the incisor canal in the maxilla, generally, in a "Y" shape; it mainly houses the nasopalatine nerve and a terminal branch of the descending nasopalatine artery, tending to increase in diameter after tooth loss, thus occupying larger parts of the atrophic anterior maxilla. The maxillary sinus has a pyramidal shape and can extend anteriorly to the canine and premolar areas and later to the maxillary tuberosity. Due to a continuous pneumatization process, the sinus expands with age and after teeth loss. Perforation of the sinus membrane is the most common complication during procedures of sinus floor elevation [17].

The teeth that come closest to the maxillary sinus, due to the proximity of their roots to the sinus mucosa, are, in decreasing order: the second molar, the first molar, the third molar, the second premolar, and the first premolar. The canine is not very close, except in partially edentulous patients where a great pneumatization of the maxillary sinus can be observed [19].

According to cross-sectional studies, the craniocaudal size of the maxillary sinuses of women is smaller than that of men, whereas the measurements of the right maxillary sinus are larger than of the left sinus [20].

Cone-beam Computed Tomography X Panoramic Radiography
Concerning the actual dimensions of the roots, the panoramic radiograph presents relatively inaccurate dimensions, with an estimated elongation of 29%, while the CBCT, tends to shorten the roots by 4% [21]. CBTC proved to be more accurate in detecting the anatomical structures mentioned here than conventional panoramic radiography images in three dimensions, under a much lower radiation dose [17].

The ratio measured in centimeters refers to the proportion between the root and the dental crown and can be presented as an R / C ratio, taking as definition parameters of an anatomical or clinical crown, and considering as a reference the line drawn from buccal to lingual or palatal at the bone level of the alveolar crest. Other studies use as a reference limit, the anatomical R / C ratio, which considers the cementoenamel junction (CEJ) as the boundary. Therefore, the studies that used panoramic radiographs had to refer to the clinical R / C ratio, since the CEJ could not be precisely determined on these radiographs [22-24]. In the study by Kim et al, the measurements based on CBCT and direct measurements before and after tooth extraction showed no significant difference in the length of the crown and root between measurements according to the scheme presented (Figure 1) [25]:
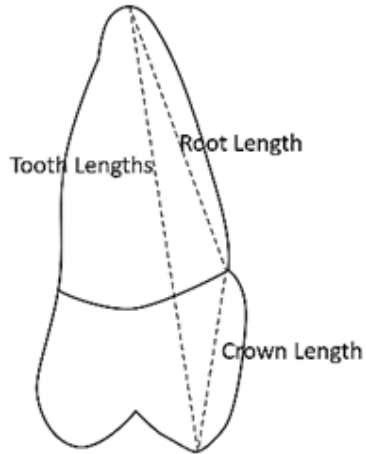
Figure 1: Draft Representing the Reference Landmarks of the Crown, Root, and Total Lengths of A Tooth, Used for Measurements in Computed Tomography [25].

In line with this reasoning, Alqerban, et al. warned that the angular differences between the tooth and the X-ray film show statistically significant effects in identifying the buccal and lingual or palatal limits of the CEJ in periapical and panoramic radiographs [26]. It is noteworthy that the anterior teeth are the most impaired in quality and accuracy of the images. Therefore, the use of the anatomical R / C ratio for measuring incisors using the CBCT is recommended, providing images in sections, without distortions that facilitate the investigation of crown and tooth root lengths, as well as the identification of lesions or the level of bone loss [27].

Even in unexpected conditions such as inclined root resorption, Alamadi, et al, concluded that CBCT is the most accurate technique for measuring and punctuating possible inclined root resorption [28].

However, as studied by Eliasson, et al, the difference in the average root length and the average height of the alveolar bone at an average of 0.97 mm, in healthy teeth and without signs of periodontal problems, that is, from the cementoenamel junction to the interdental septum, this difference corresponds [29]. Therefore, in this study, publications with data based on CBCT were selected, or when the measurements were obtained directly from extracted teeth.

Late implants X Immediate Implants - Advantages and Disadvantages

Immediate implants present some advantages over late implants, namely: A single surgical procedure; shorter treatment time; preservation of bone at the extraction site; lowest cost.

The higher preoperative requirements is one of the disadvantages due to the complexity of the intervention, that is, tooth extraction added to the implant installation; risk of retraction of the marginal mucosa and inability to provide primary stability (> 60) to torque (> 30Ncm) [30].

General Factors of Anatomical Variation and Dental Anomalies

Considering that in the same surgical act the tooth extraction is followed by the setting of the implant, it becomes necessary to know the possible anatomical variations and even possible dental anomalies in order to reduce the trauma to the tissues as much as possible, and a better definition of the installation site of the implant [31]. When are functionally detrimental, variations are called anomalies. According to Aren, et al, dental anomalies were observed in less than 0.5% among 2025 panoramic radiographs studied, meaning the rarity of the possibility, which can be detected through periapical radiographs [32].

General Factors of Anatomical Variation of Teeth

Although studies such as that carried out by Shehadat, et al. presented statistical analyzes that revealed the non-association between the number of roots with the sex, age, or location of the tooth, other studies point to general factors of anatomical variation, which can interfere together or independently in the dental morphology as well as in the number of roots [33]. Information such as ethnicity, age, biotype, and gender are easily obtained from the patient's medical record, as listed below. However, for a successful dental therapy, knowledge of tooth anatomy cannot be ignored. It is essential to know the normal configurations of the teeth and their variations.

Gender

Regarding the length of the tooth, and considering the patient's gender, a study conducted in Nepal found that there was no significant difference in the length of the roots and teeth between men and women [34].

Kulkarni, et al, when studying a population in the USA, carried out dental measurements and found out significant differences between male and female. Likewise, the clinical study by Reddy, et al, revealed that there is a positive association between height and length of the posterior tooth in men and women [35].

Differences in tooth size between genders have been observed in several populations. Ozaki, et al, demonstrated that these differences mainly involved diameters of the lower canine crown, generally showing the most striking difference [36]. In their studies, statistically significant sex differences at the level of 5% were observed in all parameters. The number of teeth showing differences was small for the diameter of the mesiodistal crown, but large for the buccal-lingual diameter. In Spain, studies showed a significant difference between the size of the roots of mandibular premolars, which were found larger in 39 men (16.05mm) and in 31 women (14.91mm) [37].

Ethnicity

Ethnicity must be taken into account. Choi, et al, analyzed the teeth dimensions of Koreans and compared their results with those of Yun, et al [38]. They concluded, for example, that the length of the upper central incisor teeth of Caucasian individuals was greater than the same teeth of Korean individuals. Therefore, when evaluating results, ethnicities and their measurements must be taken into account in order to establish adequate reference values.

In Pennsylvania, the first lower premolars with two separate roots were found in a greater number of black patients than in Caucasians (16.2% versus 5.5%) [39].

Intergenerational and International Trends on Biotype and Age

In a recent study carried out between 1914 and 2014 and published in the journal eLife in collaboration with the World Health Organization, 800 health researchers collected and analyzed data from more than 18 million people in 200 countries. It was found that people from different countries showed greater growth in stature. This could be partly attributed to genetics, but most height differences between individuals of different countries are due from other causes. For example, children and adolescents who are malnourished or suffering from serious illnesses will generally be shorter as adults. This is important because taller people generally live longer, and are less likely to suffer from heart disease and stroke, and taller women and their children are less likely to have complications during birth and after. However, they are also more likely to develop some types of cancer. The greatest gain in adult height in the past century occurred among South Korean women and among Iranian men, who became 20.2 cm and 16.5 cm taller, respectively. On the other hand, there has been little change in adult height in some countries in southern Sahara, Africa, and southern Asia over the century of analysis [40].

A study developed in Sirilanka, pointed out that there is no significant correlation between height and length of tooth roots [41]. Henderson and Corruccini, carried out studies on the remains of black individuals in the United States and concluded that the body height and the size of the teeth do not present an assured relation of proportionality, while other authors demonstrated that there is a positive relationship between these measures [42].

Reddy, et al., consider that the positive association between the individual's height and the length of the teeth can be very useful for any dentist in predicting the dimension of work during the treatment of the root canal and implantology, for example. The results of these studies suggest the confirmation of the hypothesis that taller individuals have longer teeth.

Ariji, et al. (1994), found that in Japanese men, the maxillary sinus presented a significant correlation with height and body weight, as well as with age [43]. As the height of the current Japanese generation is higher in comparison with the biotype of their elderly, the increase in the volume of the maxillary sinuses, in the younger ones, can be explained by the increase in height [44, 45].

According to Ozaki, et al., since the root measurements are highly correlated with the total tooth length, and there is a certain correlation between the total tooth length and the individual's height, it is correct to correlate the length of the tooth root and height of the individual [46]. This correlation is probably controlled by a general factor, which determines bone growth, which is different from the controlling factor of enamel deposition.

Variations in Root Length by Dental Group:

Although several authors have presented different measurements between teeth on the right and left sides of the dental arches, none of them reported a significant difference. Therefore, to standardize the presentation of the measurement in these cases, only the measurements on the left side of the dental arches were considered.

Upper Anterior Teeth

Mainly for their aesthetic function, the upper anterior teeth are often replaced by dental implants. Many dimensional studies were performed, some of them found a relation between root length with gender, with age for each group of teeth according to their root measurements as shown in Table 1:

Average of Upper Anterior Teeth Dimensions in Some Countries around the World:

Table 1: Average Length Measurements of Superior Anterior Teeth and Their Roots, in Seven Publications, Considering Gender and Ethnicity

Authors	Kulkarni (Chicago-USA)		Kim (Korea)		Çaliskan (Turkey)		Ozaki (Japan)		Jayawardena (Sri Lanka)		Zhou (China)		Woelfel (Ohio-USA)	
Country / Average Age	52,89		22,4	21,2	--		--		56	45	--		--	
Teeth measures	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Sample	57	78	31	31	100	100	247	40	12	55	74	25	398	
Central Incisor -	13,9	12,9	12,3	11,7	--		12,1	10,9	13,4	12,7	--	--	13,0	
Root Total	23,3	22,3	--	--	22,02		23,7	21,55	--	--	24,3	23,2	23,6	
Sample	60	81	31	31	100	100	245	40	20	47	72	27	295	
Lateral Incisor -	14,2	13,5	13,2	12,6	--		12,18	11,24	13,6	13,1	--	--	13,4	
Root Total	22,6	21,7	--	--	21,98		21,93	20,57	--	--	23,1	22,1	22,5	
Sample	57	91	31	31	100	100	159	23	--	--	--	--	321	
Canine – Root	17.8	16,1	15,8	15,2	--		15,67	14,31	--	--	--	--	16,5	
Total	26,2	24,6	--	--	25,98		26,41	24,37	--	--	--	--	26,3	

According to what is shown in the table 1, the Chinese have the longest total length of incisors. Whilst considering only the roots length, the Americans from Chicago, presented the longest roots. Japanese women had the smallest superior incisors. While considering only canines´ total length; Japanese men presented the longest, but smallest roots, confirming that the Asians have longer teeth crowns.

The dimensions of the roots of these teeth were very well described by Kulkarni, et al, in studies conducted in a population of Chicago, in the United States, where the average represents the longest roots in this data survey. In men, the roots of 57 maxillary central incisors measured 13.9 mm and the total length was 23.3 mm, whilst in women, 78 teeth presented an average of 12.9mm in their roots, and a total length of 22.3mm. In men, the roots of 57 upper central incisors measured 13.9mm, and a total length of 23.3mm. In women, 78 teeth presented a mean of 12.9mm at their roots, and total lengths were 22.3mm. On the other hand, 60 male upper lateral incisors presented roots measuring an average of 14.2 mm, and total a length of 22.6 mm, while 81 female teeth had roots with an average of 13.5 mm and a total length of 21.7 mm. Among men, 60 upper lateral incisors presented roots measuring an average of 14.2 mm, and a total length of 22.6 mm, while 81 women's teeth presented their roots with an average of 13.5 mm and the total length was 21, 7mm. Concerning the maxillary canines, 57of males and 91of females presented roots with averages of 17.8 and 16.1mm, respectively, and total lengths of 26.2 and 24.6mm, respectively. The upper canines in 57 and 91 male and female, respectively, presented roots with averages of 17.8 and 16.1 mm, respectively, and the total lengths of 26.2 and 24.6 mm respectively.

In 2013, Kim, et al, from Korea, carried out a study comparing the average lengths of the roots of the upper teeth and central incisors of men and women, and the results were significantly different.

In Turkey, Çaliskan, et al., compared the total average lengths of central, lateral and canine incisors, extracted with other findings in the literature, and their averages were 22.02mm, 21.98mm and 25.98mm, respectively, slightly smaller than the other findings.

In Japan, Ozaki, et al, studied extracted teeth and obtained real measurements. They tried to compare the averages between the right and left sides of the arches, concluding that there was no statistically significant difference. Regarding canine teeth, the data confirm other studies that showed the greatest total length, however with shorter roots, confirming that Asians have longer crown dimensions.

In Sirilanka, Jayawardena, et al, found that in 12 central incisors for men, the average root length was 13.39mm and 12.72mm for 55 similar teeth for women. In the upper lateral incisors of 20 men, the average length of their roots was 13.59 mm and of 47 of the similar teeth extracted from women, the average was 13.14 mm.

In a case study on cleft palate carried out in China, the control group provided the following statistical data: The total lengths of 74 male and 25 female upper central incisors averaged 24.3mm and 23.2mm respectively; 72 male and 27 female lateral incisors were 23.1 and 22.1 mm, respectively [47].

In Brazil, contralateral upper central incisors of the control group presented roots with an average of 12.42mm [48].

Upper Premolar Teeth

Premolar teeth play a fundamental role in maintaining the vertical dimension of the face and in the aesthetic faci76al contour, so the restoration of these aspects should be a priority for dentists. Table 2 shows the length of the roots of the maxillary first premolars, taking into account that most of these teeth have two roots.

Average of Upper Premolars Dimensions in Some Countries around the World

Table 2: Average of Length Measurements of Superior Premolars Teeth and Their Roots

Authors Country Average Age	Kulkarni (Chicago-USA) 52,89		Kim (Korea) 22,4 21,2		Çaliskan (Turkey)		Ozaki (Japan)		Woelfel (Ohio-USA)		Nazeer (Pakistan)	
Teeth measures	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Sample	43	54	21	21	100		252	35	234		114	
First Premolar	13,8	13,0	13,24	12,4	--		12,81	11,7	13,4		--	
Root / Total	21,4	20,1	--	--	20,49		21,07	20,37	21,5		20,0	
Sample	30	42	21	21	100		250	33	224		115	
Second Premolar	14,6	12,9	13,18	12,55	--		13,62	12,66	14,0		--	
Root / Total	21,8	19,8	--	--	21,06		21,07	20,05	21,2		19,8	

Table 2 show results in six publications, considering gender and ethnicity. Comparing this data, U.S. Americans present the longest roots and total length of premolars, confirmed by two of the authors.

In the data survey by Kulkarni, et al., (2020) carried out with a population of Chicago in the United States, root length averages was the longest in comparison with other authors' data., consistent with those obtained by Woelfel, in Scheid and Weiss [49].

Çaliskan, et al. (1995) measured extracted teeth in Turkey, with no records of their origin, and the averages of the total lengths of the first and second premolars were 19.8 mm and 20.5 mm, respectively.

One point to observe is that in a Korean study carried out by Kim, et al. (2013), the measurements were made both by CBCT as directly on extracted premolar teeth, and results showed significance only on the root and crown´s measurements. With respect to total length, the CBCT-based measurements were 0.18 ± 0.44 mm shorter than the direct measurements (p < 0.001). Furthermore, the total length measured directly on premolars was on average 21.55 ± 1.59 mm.

Table 3 shows the greatest variability in the number of roots of the first premolars. Teeth with only one root were 15.5% in Poland to 72,2% of cases in China, confirmed by two other authors, that the Chinese population have mainly only one rooted first upper premolar.

Percentage of Upper First Premolar Concerning the Number of Rootsin Countries around the World

Table 3: Distribution of the Number of Roots of Superior First Premolars Teeth, Around The World.

Single Root (%)	Double Roots (%)	Triple Roots (%)	Sample (n)	Population	Authors/year
15,5	74,0	9,0	142	Poland	Lipski, et al (2005)
26,7	73,3	0,0	202	Ugandan	Rwenyonyi, et al. (2011)
17,9	80,9	1,2	246	Saudi Arabia	Athie, (2008)
30,8	68,4	0,8	600	Jordan	Awawdeh, et al (2008)
31,5	68,5	0,0	114	Pakistan	Nazeer, et al. (2018)
37,3	61,3	1,3	300	Turkey	Kartal, et al. (1998)
37,0	57,0	6,0	100	West Virginia	Carns & Skidmore (1973)
40,0	56,7	3,3	150	Spain	Chaparro, et al. (1999)
49,4	50,6	0,0	957	Singapura	Loh, H. S. (1998)
53,6	46	0,4	250	India	Gupta, et al. (2015)
54,3	44,8	0,9	437	Turkey	Celikten, et al (2016)
54,8	44,4	0,8	250	Iemen	Senan, et al. (2018)
55,8	41,7	2,5	240	Brazil	Pécora, et al. (1991)
60,0	40,0	0,0	100	China	Waker, T. B. (1987)
67,4	32,0	0,55	1268	China	Wu D, et al. (2020)
72,2	26,5	1,23	324	China	Liu, X., et al. (2019)

Kulkarni, et al. (2020), when studying the roots of upper second premolars in the American population, found that in 30 men's teeth and 42 women's teeth, the mean total length was 21.8 and 20.8 mm, respectively. These findings are consistent with the data obtained by Scheid and Weiss (2010) on the 224 roots with a length of 21.2 mm. In other findings in the Pakistani population, Nazeer, et al., found an average of 19.85 mm in the total length of 115 teeth [50]. As for the roots, they also observed that 84.3% had a single root and 15.7% two roots. Other authors have found the incidence of 91.6% of single-rooted, 7.6% of double-rooted, and 0.4% of tri-rooted [51].

Lower Anterior Teeth

The reduction and maintenance of bone anatomy in both the buccal-lingual and vertical dimensions of the alveolar crest, commonly observed after tooth extraction, can be explained by physiological principles and requires a certain daily stimulus of stress/deformation [52]. Clinicians should also remember that, after tooth extraction, the alveolar bone is reabsorbed and the incisor canal may be closer than expected to the alveolar crest, resulting in a shallow vestibule with an insufficient depth of the oral floor [53].

Many authors performed investigations on dimensions of lower incisors and canines, as shown in Table 4:

Average of Lower Anterior Teeth´S Dimensions in Some Countries around the World

Table 4: Average of Length Measurements of Mandibular Anterior Teeth and Their Roots.

Authors	Kulkarni		Kim		Çaliskan		Ozaki		Haghanifar		Leoni /Versiani	Woelfel
Country	(Chicago-USA)		(Korea)		(Turkey)		(Japan)		(Iran)		(Brazil)	(Ohio-USA)
Average Age	52,89		22,4	21,2					47,3	41,5		
INFERIOR Teeth measures	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂ ♀	♂ ♀
Sample	104	154	31	31	100	100	244	32	146	171	50	226
Central Incisor – Root	13,7	12,7	11,56	10,99	--		11,4	10,84	13,9	12,8	--	12,6
Total	21,0	20,0	--	--	20,81		19,9	19,1	20,93	20,01	20,71	21,4
Sample	102	158	31	31	100	100	244	36	172	199	50	234
Lateral Incisor – Root	14,3	13,3	12,75	12,58	--		12,44	11,93	14,96	14,4	--	13,5
Total	22,1	21,2	--	--	21,55		21,36	20,52	22,48	21,99	21,56	23,1
Sample	96	163	31	31	100	100	145	26	165	203	100	316
Canine – Root	16,6	15,5	15,02	14,21	--		14,56	13.0	17,04	15,85	15,57	15,9
Total	25,0	23,0	--	--	22,86		25,37	23,04	25,5	24,01	--	26,9

Table 4 shows the average of length measurements of mandibular anterior and their roots in eight publications, considering gender and ethnicity. Comparing this data, Iranian population may present the longest roots and total length in all the anterior lower teeth, and women from Japan the shortest ones. Two articles from Brazil were put together, since one had studied only canines and the other the incisors.

In the survey carried out by Kulkarni, et al., (2020) in a population of Chicago, in the United States, the average total length of the teeth was 21.0 and 20.0 mm for men and women, respectively. Regarding mandibular lateral incisors, the same means were 102 male teeth, 14.3 mm and 158 female teeth, 13.3; while the measurements of the total length of the teeth were 22.1 and 21.2 respectively between men and women. The average total tooth length was 21.0 and 20.0mm for men and women, respectively. Regarding the lower lateral incisors, the same averages were 14.3 mm for 102 male teeth, and 13.3mm for 158 female teeth. The measures of the total length of the teeth were 22.1 and 21.2 respectively for men and women. On the other hand, canines presented averages in total averages of 25 and 23mm respectively in men and women.

In an Iranian population, 632 central, 614 lateral, and 608 canine incisors were selected, whose total length averages presented 21.3, 21.9, and 25.1 mm respectively [54]. Confirming this trend, another study in the same population presented more detailed results, as shown in Table 4, in which the largest roots were observed for both Iranian men and women: 13.9 and 12.8 mm for central incisors,

14.96 and 14.4mm for the lateral incisors, and 17.04 and 15.85 for the canines, all inferior, respectively, Haghanifar, et al., [55].

According to the studies by Ozaki et al (1988) carried out in Japan, the dental crowns of the mandibular anterior teeth stand out proportionally with the roots, as they are the shortest, in general. However, their overall lengths are among the largest dimensions, as is the case with the canine, for example. This trend was also observed in the upper teeth.

In Brazil, an analysis of extracted lower canines was selected as they presented a square root whose measurements ranged from 12.53 to 18.08 mm [56, 57]. Leoni, et al, carried out another study, in 612 single roots lower incisors extracted and collected from a Brazilian population. The average total length of the central and lateral lower incisors was 20.71mm and 21.56mm, respectively, with no statistically significant difference between them (P> 0.05).

Çaliskan, et al. (1995) measured extracted teeth in Turkey, without records of their origin, and the average lengths of the central, lateral, and lower canine incisors were 20.81mm, 21.55mm, and 22.86mm, respectively.

Lower Premolar Teeth
The lower and upper premolars play an esthetic role beyond the masticatory function. After a tooth extraction, the alveolar crest closeness to mental foramen is increased, due to the resorption of the alveolar bone surrounding lower premolar´s roots, the fastest rate of resorption area after tooth extraction.

Average of Lower Premolars´ Dimensions in Some Countries around the World

Table 4: Average of Length Measurements of Mandibular Premolar Teeth and Their Roots.

Authors	Kulkarni		Kim		Çaliskan		Ozaki		Llena		Woelfel	
Country	(Chicago-USA)		(Korea)		(Turkey)		(Japan)		(Spain)		(Ohio-USA)	
Average Age	52,89		22,4	21,2					45,2			
INFERIOR Teeth measures	🚹	🚺	🚹	🚺	🚹	🚺	🚹	🚺	🚹	🚺	🚹	🚺
Sample	78	129	31	31	100	100	221	34	39	31	238	
First Premolar	15,2	14,3	13,77	13,56	--		13,36	12,78	15,6		14,4	
Incisor - Root / Total	22,2	21,1	--	--	21,22		21,67	20,76	22,3		23,2	
Sample	53	93	31	31	100	100	215	33	39	31	227	
Second Premolar	15,0	14,0	13,58	13,16	--		13,48	12,97	15,0		14,7	
Incisor – Root / Total	22,0	20,0	--	--	21,63		20,97	20,1	21,8		22,9	

Table 4 shows the average of length measurements of mandibular premolar teeth and their roots in six publications, considering gender and ethnicity. Comparing this data, the population from Spain may present the longest roots, but considering the total length, confirmed by two of the authors from USA, the Americans may have the longest, while women from Japan have the shortest total length teeth, and their roots.

In the data survey by Kulkarni, et al., (2020) carried out in a population of Chicago, in the United States, among men, the root length averages of 78 upper first premolars were 15.2 mm, while that of the 129 similar teeth in women was 14.3mm. The average total tooth length was 22.2 and 21.1 mm for men and women, respectively, while in the state of Ohio, the total measurement of teeth was 23.2 and 22.9 mm for the mandibular first and second premolars, respectively. In the second premolars, the average root length for 53 men was 15.0mm, for women it was 14.0mm for 93 similar teeth. The average total tooth length was 22.0 and 20.0mm for men and women, respectively.

The average length of the roots was 15.56 mm (CI: 15.25-15.86) (men: 16.05 mm, CI: 15.64-16.46; women: 14.91 mm, CI: 14, 50-15.32). Men's roots were significantly longer than women's were (p = 0.00) [57].

In Spain, the average length of the roots was significantly longer in men than of women, 16.05 and 14.91mm, respectively (p = 0.00) [58-72].

Molar Teeth
Most maxillary and mandibular molars present many anatomical variations, making it difficult to establish a pattern that can serve as a reference, especially regarding the number and length of the roots. In this case, it is better to resort to imaging tests, preferably using computed tomography, and prior to immediate implantation.

Conclusion
Considering the importance of anatomical knowledge prior to the placement of immediate implants, the present study sought to synthesize these possible variations. The dimensions of the roots of the teeth to be extracted, immediately before the implant installation, can serve as a basis for prior implant choice. Considerations include general factors of variation such as age, biotype, gender, and ethnicity.

Some authors found significant differences when comparing people presenting these various factors. Age is a factor that can be explained in two ways by the natural wear of the teeth, especially the incisal edges, which can interfere with the total length of the teeth. However, it is observed that the younger generations are taller, correlating the biotype factor. Thus, some authors consider the positive correlation of height and length of the roots, while others did not find these correlations, suggesting that further studies should be carried out.

The same was observed in relation to gender, most authors considered that men have significantly longer average lengths than women do. As for ethnicity, once again we observed the correlation between the factors of variation, when intergenerational differences were observed through changes in diet and lifestyle, mainly due to the physical exercises, which also tend to influence the biotype. An example of this is what happened in South Korea, where women have gained more than 20cm in height in the last century.

This study showed that with regard to the variation in the number of roots of the same tooth in the world population, there is no staggered distribution in the world population of the same characteristic. Therefore, in general, this variation of number of roots, among people around the world is not correlated to a specific ethnicity.

With these data gathered, it can be reaffirmed that anatomical variations are factors that can influence the constitution and length of the roots. These factors can be considered from data obtained from the first moment of the evaluation and anamnesis and may serve to predict the likely size of the implant, based on the individual's bone structure, even before imaging exams, which may allow the final dimensioning of the implant to be installed immediately after tooth extraction. It appears that the association between height and dimensions of teeth is dependent on the tooth

studied, ethnicity, and gender, but also on the generation of the population studied.

More studies must be performed using imaging exams, as Cone-Beam Computed Tomography, with more complete data as gender, height and age.

References
1. Adell R, Hansson BO, Branemark P-I, E Breine U (1969) Intra-osseous Anchorage of Dental Prostheses. I. Experimental Studies. Scand J Plast Reconstr Surg 3: 81-100.
2. Miguel JrH, Genovese WJ, Beltrão CFB, Kassardjan F, Cerri A (2016) Implante imediato associado ao enxerto de tecido conjuntivo - relato de caso clínico. Rev Assoc Paul Cir Dent 70: 312-316.
3. Carvalho AAB, Corrêa LAAF, Freitas FF, e Dias PC (2017) Importância da Tomografia Computadorizada de Feixe Cônico na avaliação de canino incluso na maxila. Rev Bras Odontol abrl/jun 74: 143-149.
4. Araújo MG, Wennstrom JL, e Lindhe J (2006) Modeling of the buccal and lingual bone walls of fresh extraction sites following implant installation. Clinical Oral Implants Research 17: 606-614.
5. Lee J-S, Sohn J-Y, Lim H-C, Jung U-W, e Choiet S-H (2015) Different bone regeneration patterns in periimplant circumferential gap defects grafted with two types of osteoconductive biomaterial. J. Biomedical Materials Research B: Applied Biomaterials 2015: 1-8.
6. Bosshardt DD, Zalzal S, Mckee MDE, Nanci A (1998) Developmental Appearance and Distribution of Bone Sialoprotein and Osteopontin in Human and Rat Cementum. The Anatomical Record 250: 13-33.
7. Hong CE, Lee J-Y, Choi Je, Joo J-Y (2015) Prediction of the alveolar bone level after the extraction of maxillary anterior teeth with severe periodontitis. J Periodontal Implant Sci 45: 216-222.
8. Guerra I (2014) Preservação do alvéolo pós-extracção: indicações, alterações biológicas, resultados clínicos. Instituto Superior De Ciências Da Saúde Egas Moniz. Tese - Mestrado Integrado Em Medicina Dentária 2014: 12.
9. Schropp L, Kostopoulos L, Wenzel A (2003) Bone healing following immediate versus delayed placement of titanium implants into extraction sockets: a prospective clinical study. Int J Oral Maxillofacial Implants. Mar-Apr 18: 189-199.
10. Cardaropoli G, Araújo M, Lindhe J (2003) Dynamics of bone tissue formation in tooth extraction sites. An experimental study in dogs. J Clin Periodontol. Sep;30(9):809-18.
11. Chen J, Cai M, Yang J, Aldhohrah T, Wang Y (2019) Immediate versus early or conventional loading dental implants with fixed protheses. A systematic review and meta-analysis of randomized controlled clinical trials. The J. of Prothetic Dentistry 122: 516-536.
12. Gomez-Roman G, Kruppenbacher M, Weber H, Schulte W (2001) The International Journal of Oral & Maxillofacial Implants 503 Immediate Postextraction Implant Placement with Root-Analog Stepped Implants: Surgical Procedure and Statistical Outcome After 6 Years. Oral Maxillofac Implants 16: 503-513.
13. Angelis N, Sorrenti E, Modena C, Benedicenti S (2016) Evaluation of primary stability of single implants placed in fresh extraction sockets - a clinical trial. Biotechnology 30: 354-359.
14. Esposito M, Koukoulopoulou A, Coulthard P, Worthington HV (2010) Interventions for replacing missing teeth - dental implants in fresh extraction sockets. Eur J Oral Implantol 3: 189-205.
15. Garcia JJ, Sanguino D (2014) A new protocol for immediate implants - The rule of the 5 triangles - A case report. Inspyred-The alternative European Association of Osseointegration voice. Winter 2: 5-9.
16. Rojo-Sanchis J (2021) Facial alveolar bone thickness and modifying factors of anterior maxillary teeth - a SR and M-A of CBCT studies. BMC Oral Health 21: 143.
17. Ramanauskaite A, Becker J, Sader R, Schwarzet F (2019) Anatomic factors as contributing risk factors in implant therapy. Periodontol 81L 64-75.
18. Zekry A, Wang R, Chau ACM, Lang NP (2013) Facial alveolar bone wall width - a cone-beam computed tomography study in Asians. Clinical Oral Implants Research 25: 194-206.
19. Gu Y (2018) Evaluation of the relationship between maxillary posterior teeth and maxillary sinus floor using CBTC. BMC Oral Health 18: 164.
20. Amin MF, Hassan EI (2012) Sex identification in Egyptian population using Multidetector Computed Tomography of the maxillary sinus. Journal of Forensic and Legal Medicine 19: 65-69.
21. Flores-Mir M, Rosenblatt MR, Major PW, Carey JP, Heo G (2014) Measurement Accuracy and Reliability of Tooth Length on Conventional and CBCT Reconstructed Panoramic Radiographs. Dental Press J Orthod 19: 45-53.
22. Kulkarni V, Duruel O, Ataman-Duruel ET, Tözüm Nares S, Tözüm TF (2019) In-depth morphological evaluation of tooth anatomic lengths with root canal configurations using cone beam computed tomography in North American population. Journal of Applied Oral Science 28: e20190103.
23. Yun H-J, Jeong J-S, Pang N-S, Kwon I-K, Jung B-Y (2014) Radiographic assessment of clinical root-crown ratios of permanent teeth in a healthy Korean population. The Journal of Advanced Prosthodontics 6: 171-176.
24. Penny RE, Kraal JH (1979) Crown-to-root ratio - Its significance in restorative dentistry. The Journal of Prosthetic Dentistry 42: 34-38.
25. Kim S-Y, Lim S-H, Gang S-N, Kim H-J (2013) Crown and root lengths of incisors, canines, and premolars measured by CB CT in patients with malocclusions. Korean J Orthod 43: 271-278.
26. Alqerban A, Jacobs R, Fieuws S, Willems G (2011) Comparison of two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. The European Journal of Orthodontics 33: 93-102.
27. Lund H, Gröndahl K, Gröndahl HG (2010) Cone beam computed tomography for assessment of root length and marginal bone level during orthodontic treatment. Angle Orthod 80: 466-473.
28. Alamadi E, Alhazmi H, Hansen K, Lundgren T, Naoumova J (2017) A comparative study of cone beam computed tomography and conventional radiography in diagnosing the

extent of root resorptions. Progress in Orthodontics 18: 1-8.

29. Eliasson S, Lavstedt S, Ljungheimer C (1986) Radiographic study of alveolar bone height related to tooth and root length. Community Dent Oral Epidemiol 14: 169-171.

30. Al-Sabbagh M, Kutkut A (2015) Immediate Implant Placement – Surgical Techniques for Prevention and Management of Complications. Dent Clin N Am 59: 73-95.

31. Luder HU (2015) Malformations of the tooth root in humans. Frontiers in Physiology 6: 1-6.

32. Aren G, Güven Y, Tolgay CG, Ozcan İ, Bayar ÖF, et al. (2015) The Prevalence of Dental Anomalies in A Turkish Population. Journal of Istanbul University Faculty of Dentistry 49: 23.

33. Shehadat SA, Waheb S, Bayatti SWA, Kheder W, Khalaf K, et al. (2019) Cone Beam Computed Tomography Analysis of Root and Root Canal Morphology of First Permanent Lower Molars in a Middle East Subpopulation. Journal of International Society of Preventive & Community Dentistry 9: 458-463.

34. Dashrath K, Nisha A, Subodh S (2015) Root Morphology and Tooth Length of Maxillary First Pré-molar In Nepalese Population. Dentistry 5: 324.

35. Reddy S, Shome B, Patil1 J, Koppolu P (2017) A Clinical Correlation Between Stature and Posterior Tooth Length. Pan African Medical Journal 26: 17, 1-10.

36. Ozaki T, Satake T, Kanazawa E (1988) Morphological significance of root length variability in comparison with other crown dimensions. II. Correlation between crown and root measurements. Journal of Nihon University School of Dentistry 30: 11-21.

37. Llena C, Fernandez J, Ortolani PS, Forner L (2014) Cone-beam computed tomography analysis of root and canal morphology of mandibular premolars in a Spanish population. Imaging Science in Dentistry by Korean Academy of Oral and Maxillofacial Radiology 44: 221-227.

38. Choi S-H, Kim J-S, Kim C-S, Yu H-S, Hwang C-J (2017) Cone-beam computed tomography for the assessment of root–crown ratios of the maxillary and mandibular incisors in a Korean population. The Korean Journal of Orthodontics 47: 39.

39. Trope M, Elfenbein L, Tronstad L (1986) Mandibular Premolars with More Than One Root Canal in Different Race Groups. Journal Of Endodontics 12: 343-35.

40. Bentham J (2016) A century of trends in adult human height. NCD Risk Factor Collab. eLife; 5 – 13410: 1-29.

41. Jayawardena CK, Abesundara AP, Nanayakkara DC, Chandrasekara MS (2009) Age-related changes in crown and root length in Srilankan Sinhalese. J Oral Sci 51: 587-592.

42. Henderson AM, Corruccini RS (1976) Relationship Between Tooth Size and Body Size in American Blacks. Journal of Dental Research 55: 94-96.

43. Ariji Y, Kuroki T, Moriguchi S, Ariji E, Kanda S (1994) Age changes in the vol. of the human maxillary sinus -CT. Dentomaxillofacial Radiology 23: 163-168.

44. Kim S-Y, Lim S-H, Gang S-N, Kim H-J (2013) Crown and root lengths of incisors, canines, and premolars measured by cone-beam computed tomography in patients with malocclusions Korean Journal Orthod 43: 271-278.

45. Çalişkan MK, Pehlivan Y, Sepetçioğlu F, Türkün M, Tuncer SS (1995) Root Canal Morphology of Human Permanent Teeth in a Turkish Population. Journal of Endodontics 21: 200-204.

46. Ozaki T, Satake T, Kanazawa E (1987) Morphological significance of root length variability in comparison with other crown dimensions. I. Basic statistics and sex difference. Journal of Nihon University School of Dentistry 29: 233-240.

47. Zhou W, Li W, Lin J, Liu D, Xie X, et al, (2013) Tooth Lengths of the Permanent Upper Incisors in Patients with Cleft Lip and Palate Determined with Cone Beam Computed Tomography. The Cleft Palate-Craniofacial Journal 50: 88-95.

48. Rizzatto SMD, Menezes LM, Rabin P, Petersen RC, Mattiello FDL, et al. (2017) Crown and Root Lengths of Impacted Maxillary Central Incisors and Contralateral Teeth Evaluated with Cone Beam Computed Tomography. Pesquisa Brasileira em Odontopediatria e Clinica Integrada 17: e3613.

49. Scheid RCS, Weiss G (2010) Woelfel´s Dental Anatomy. 8th ed. Lippincott, Williams & Wilkins. Philadelphia, USA.

50. Nazeer MR, Khan FR, Ghafoor R (2018) Evaluation of root morphology and canal configuration of Maxillary Premolars in a sample of Pakistani population by using Cone Beam Computed Tomography. Journal of the Pakistan Medical Association 68: 423-427.

51. Celikten B, Orhan K, Aksoy U, Tufenkci P, Kalender A, et al. (2016) Cone-beam CT evaluation of root canal morphology of maxillary and mandibular premolars in a Turkish Cypriot population. BDJOpen 2: 15006.

52. Hansson S, Halldin A (2012) Alveolar ridge resorption after tooth extraction: A consequence of a fundamental principle of bone physiology. Journal of Dental Biomechanics 3.

53. Romanos G, Greenstein G (2008) The Incisive Canal. Considerations During Implant Placement: Case Report and Literature Review. The International Journal of Oral & Maxillofacial Implants 24: 740-745.

54. Aminsobhani M, Sadegh M, Meragi N, Razmi He, Kharazifard MJ (2013) Evaluation of the root and canal morph. of mand. permanent anterior teeth in an Iranian pop. By Cone-Beam Computed Tomography. J Dent (Tehran) 10: 358-366.

55. Haghanifar S, Moudi E, Bijani Ae, Ghanbarabadi KM (2017) Morphologic assessment of mandibular anterior teeth root canal using CBCT. Acta Medica Academica 46: 85-93.

56. Versiani MA, Pecora JD, e Sousa-Neto MD (2013) Microcomputed tomography analysis of the root canal morphology of single-rooted mandibular canines. International Endodontic Journal 46: 800-807.

57. Leoni GB, Versiani MA, Pécora JD, Sousa-Neto MD (2014) Micro–Computed Tomographic Analysis of the Root Canal Morphology of Mandibular Incisors. JOE Maio 40: 710-716.

58. Lipski M, Woźniak K, Łagocka R, Tomasik M (2005) Root and canal morphology of the human maxillary first premolar. Durham Anthropol J 12: 2-3.

59. Rwenyonyi CM (2011) Root and Canal Morphology of Maxillary First Premolar Teeth in a Ugandan Population. Open Journal of Stomatology 1: 1.

60. Atieh MA (2008) Root and canal morphology of maxillary first premolars in a Saudi population. J Contemp Dent Pract 9: 46-53.

61. Awawdeh L, Abdullah H, Al-Qudah A (2008) Root Form and Canal Morph. of Jordanian Max. 1st. Premolars. J. Endodontics 34: 956-956.

62. Nazeer MR, Khan FR, Ghafoor R (2018) Evaluation of root morphology and canal configuration of Maxillary Premolars in a sample of Pakistani population by using Cone Beam Computed Tomography. J Pak Med Assoc 9: 46-53.

63. Kartal N, Ozcelik B, Cimilli H (1998) Root canal morphology of maxillary premolars. J Endod 24: 417-419.

64. Carns EJ, Skidmore AE (1973) Configurations and deviations of root canals of maxillary first premolars. Oral Surgery, Oral Medicine, Oral Pathology 36: 880-886.

65. Chaparro AJ, Segura JJ, Guerrero E, Jimenez-Rubio A, Murillo C, et al. (1999) Number of roots and canals in maxillary first premolars: study of an Andalusian population. Dental Traumatology 15: 65-67.

66. Loh HS (1998) Root morphology of the maxillary first premolar in Singaporeans. Australian Dental Journal 43: 399-402.

67. Gupta S, Sinha DJ, Gowhar O, Tyagi SP, Singh NN, et al. (2015) Root and canal morphology of maxillary first premolar teeth in north Indian population using clearing technique: An in vitro study. Journal of conservative dentistry : JCD 18: 232-236.

68. Senan EM, Alhadainy HA, Genaid TM, Madfa AA (2018) Root form and canal morphology of maxillary first premolars of a Yemeni population. BMC Oral Health 18.

69. Walker RT (1987) Root form and canal anatomy of maxillary first premolars in a southern Chinese population. Endod Dent Traumatol 3: 130-134.

70. Liu X, Gao M, Ruan J, Lu Q (2019) Root Canal Anatomy of Maxillary First Premolar by Microscopic Computed Tomography in a Chinese Adolescent Subpopulation. BioMed Research International 2019: 1-9.

71. Wu D, Hu Dq, Xin Bc, Sun Dg, Ge Zp, et al. (2020) Root canal morphology of maxillary and mandibular first premolars analyzed using cone beam computed tomography in a Shandong Chinese population. Medicine 99: 20(e20116).

72. Pan JYY, Parolia A, Chuah SR, Bhatia S, Mutalik S, et al. (2019) Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. BMC Oral Health 19.