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Original Article

Morphological study of the mandible using digital panoramic x-rays, Part I: The canal of Serres, prevalence and location

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ABSTRACT

Introduction: The canal of Serres (CS) is located inferior to the mandibular canal (MC) and is highly developed in the fetus and from the birth it tends to obliterate and disappear. The purpose of this research was to establish prevalence and position of CS through digital panoramic x-rays and to propose a term to call it in agreement with International Anatomical Terminology.
Methods: Cross-sectional study which analyzed 500 digital panoramic x-rays. Exclusion criteria were applied and the presence and location of CS was determined. The anteroposterior length of CS and its distance from the dental apices was measured.
Results: 495 x-rays were included (297 women; 198 men). The prevalence of CS was 10.51%. Always, the CS was situated in a position inferior to the MC. Of the total, 36.54% had the CS on the right mandibular side (n = 19), 25% on the left (n = 13) and 38.46% were bilateral (n = 20). The CS was identified 57.69% in men (n = 30) and 42.31% in women (n = 22). Greater prevalence was found in the first and second decade of life (28.85% (n = 15) and 38.46% (n = 20), respectively). The average length was 19.59 ± 5.29 mm (20.86 ± 5.11 mm and 18.08 ± 5.18 mm for the right and left side respectively).
Discussion: Our study shows a lower prevalence than others authors and it is not always possible to find the bilateral CS at any age; however, it is predominant in subjects under 20 years. The term "inframandibular canal" is proposed for the CS, considering its direction parallel to and below the MC.

1. Introduction

The canal of Serres (CS) was described for the first time in 1817 as a canal located inferior to the mandibular canal and through which an artery ran independently. This canal is highly developed in the fetus[1] and from the birth it tends to be obliterated and disappear,[2] with a percentage of presence significantly lower in adults.[3,4] The canal may originate in a foramen located on the medial surface of the mandibular ramus, posterior to the mandibular foramen,[5] and finish in a foramen located in the canine region, anterior to the mental foramen.[1] Although the CS was discovered and described almost two centuries ago, it has not generally been considered in research and has come to be called by some authors the "canal that dentistry ignores".[6]

Two theories have been posited in relation to the contribution of this canal to the development of the mandibular structures. The first theory was proposed by the discoverer of the canal[1] and this has been confirmed in other publications[7] establishing that the artery contained in the CS playing a role in the vascularization of the primary teeth, and therefore it was called the "conduct of the primary teeth". However, susbequent investigations indicate that the existence of the CS, as well as the function of its vessels, seems to be related to the ossification process of the mandible, since it is topographically related to the mandibular symphysis and not to the tooth buds,[8] and therefore the original denomination given the canal would be incorrect. On the other hand, Brun[9] and Rodriguez-Vazquez et al.[8] described a "definite vein" formed by the confluence of venous drainage from both areas of mandible ossification; endochondral ossification of Meckel's cartilage and membranous ossification of the symphyseal region of mandible. This vein is separated from the inferior alveolar nerve, artery and vein, in an independent bony canal. This seems to be the accepted theory today for the embryologic origin of vein and CS.

The presence of the CS has been documented mainly through anatomical studies.[8] To the best of our knowledge we found no publications referring to the possibility that this canal could be detected through x-rays commonly used in dentistry, such as the panoramic x-ray, nor any reports on detecting the prevalence of

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this canal using x-rays, even though nowadays the quality of the panoramic image has improved substantially. By consensus it is known that the mandibular canal is a structure of great importance in clinical practice and although many studies describe it as a bilateral and single canal, there are reports in the literature that demonstrate the presence of a second and even third accessory mandibular canal.[10] Schilling et al.[11], in a sample of 350 digital panoramic x-rays, describe 5% of these as bifurcations of the mandibular canal. When this variability is found, it is important to define when there is an accessory mandibular canal, a bifid mandibular canal or the so-called CS.

The presence of an accessory mandibular canal is expressed during embryonic development, in which the three branches of the inferior alveolar nerve are fused.[12] When the fusion of some of these nerve branches is incomplete, the tissue around it will be ossified, giving rise to an accessory mandibular canal.[13] The term bifid is derived from the Latin and means division into two parts or branches[14]; thus, a bifid mandibular canal involves the communication of two canals, or from another point of view the cleavage of one, and therefore it would fall within the classification of an accessory mandibular canal. However, when we speak of the CS we must refer to its origin and formation, which was investigated by Rodríguez-Vázquez et al.[8] and described in the previous paragraph. The CS and its content ran separately from the inferior alveolar vasculonervous package and its canal (mandibular canal). This is the reason why the CS has no direct connection with the mandibular canal, in contrast to an accessory mandibular canal which has the same origin and possesses a communication with it.

The aim of this study was to establish the prevalence and position of the canal of Serres (CS) through digital panoramic x-rays from a sample of Chilean patients in different age ranges.

2. Materials and methods

A cross-sectional study was conducted with the approval of the Scientific Ethics Committee of the Universidad de La Frontera (file n° 015/2014). Digital panoramic x-rays (1:1 ratio), taken between January 2010 and October 2014 in the Dentistry Teaching Clinic of the Faculty of Dentistry, Universidad de La Frontera, Temuco, Chile, were analyzed. The x-rays were taken using a standard technique with the PAX-400C orthopantomograph (VATECH, Korea, 2010).

All the x-rays used in the study belonged to patients of known age and sex. The following exclusion criteria were applied: x-rays with distortion or alteration in the contrast, x-rays revealing a pathology, teeth included or titanium plates in the mandibular area, and x-rays with evidence of orthognathic surgery in the mandibular area.

In order to obtain the best image quality, the method described in a similar analysis of anatomical structures through the use of digital panoramic x-rays was used.[15] All the x-rays were reviewed using Adobe Photoshop CS3 (v. 10.0; Adobe Systems Incorporated) to adjust the level, color and contrasts of the image. Then AutoCAD (2010 version; Autodesk) was used to take the measurements between the different anatomical references observed on the panoramic x-ray. The size of the x-ray was adjusted by the measurement software as per the parameters indicated by the orthopantomograph software so that the measurement scale was not altered.

The panoramic x-rays were analyzed by a single operator. Intraobserver agreement was evaluated by means of duplicated examinations of all the x-rays studied. There was a one-week interval between the first and second measurements.

The CS was classified as present where a canal independent of the mandibular canal was observed, that was uniform in diameter, with defined corticals and which was, along its entire trajectory, in a position inferior to the mandibular canal (Fig. 1).

For the cases where an entrance and/or exit foramen from the CS was distinguished, the following classification was given: the position of the entrance foramen was established with respect to the mandibular foramen and thus it was classified as inferior, superior or in line (Fig. 2). The position of the exit foramen was established with respect to the mental foramen and thus it was classified as posterior, in line or anterior (Fig. 2). The reference lines used for this classification correspond to a tangential horizontal straight line to the lower edge of the mandible (L1), a straight line parallel to L1 that passes through the center of the mandibular foramen (L2) and a straight line perpendicular to L1 that passes through the center of the mental foramen (L3).

The anteroposterior length of the entire trajectory of the CS was measured from the most posterior to the most anterior point of the canal visible on the panoramic x-ray (Fig. 2). The distance between the CS and the apices of the teeth that were in its trajectory was established and in order to do this the longitudinal axis of each tooth and its projection on the canal was used (Fig. 2).

The data were analyzed using descriptive statistics (mean ± SD): the Kolgomorov-Smirnov test of normality, t-test for independent samples, Pearson's chi-squared test and a one-way ANOVA were applied. The data were analyzed with SPSS/PC + v.

Fig. 1. Digital panoramic x-rays of 8 years old patient. ***White arrow***: mandibular canal. ***Blue arrow:*** CS.

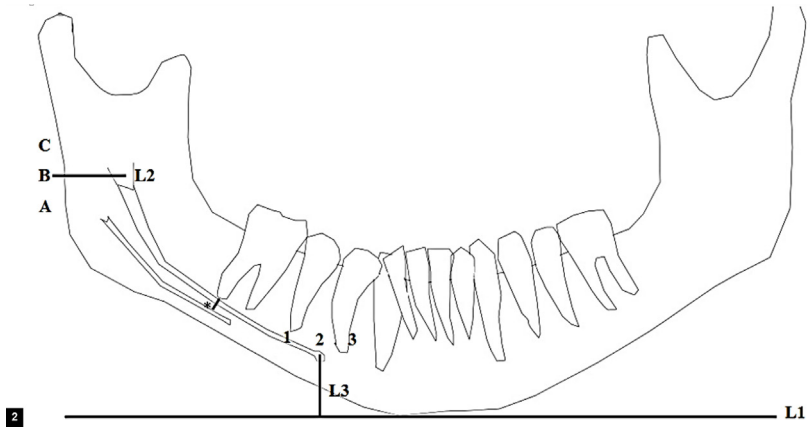

Fig. 2. Diagram jaw with measurement lines. This diagram show the position of the CS entrance foramen (A, B or C) using the mandibular canal foramen as a reference. In the same way, the position of exit foramen was classified using the mental foramen as a reference (1, 2 or 3). The distance between CS and the dental apices was determined too (*).

20.0 (SPSS, Chicago, IL) software and a p value <0.05 was considered significant.

3. Results

The digital panoramic x-rays taken between January 2010 and October 2014 that were accessible totaled 500 (301 women, 199 men). Once the exclusion criteria were applied five records were discarded, leaving 495 x-rays in the study (297 women, 198 men).

The intraclass correlation coefficient (ICC) that determines intraobserver agreement for the different measurements is detailed in Table 1. For all cases the ICC was 0.999 (perfect strength of agreement).

This study revealed a CS prevalence of 10.51% by radiography (n = 52) (Table 2). In all cases where the CS could be identified, it was always visualized in a position inferior to the mandibular canal, with its entrance foramen inferior to the entrance foramen of the mandibular canal and its exit foramen in a position posterior to the mental foramen (Fig. 3).

Of all the identified cases of CS, 36.54% were on the right mandibular side (n = 19), 25% (n = 13) on the left, and 38.46% were bilateral (n = 20) (Table 2). In addition, 57.69% of CS cases were identified in men (n = 30) and 42.31% in women (n = 22) (Table 3). Table 3 shows the distribution of the CS according to sex and the mandibular side on which it is situated. In the total sample, for the men the CS was present in 4.8% on the right side and 4.0% on the left, whereas for women it was 3.0% on the right and 2.6% on the left. Statistically significant differences were found when the presence of the CS on the right and left sides was compared according to sex (p = 0.004 and p = 0.012 respectively, Tables 4 and 5).

With respect to the distribution of the CS according to age, a greater prevalence was found in the 1st and 2nd decade of life (0–9 and 10–19 years, respectively) with 28.85% (n = 15) and 38.46% (n = 20) respectively, whereas the lowest prevalence was recorded in the 4th decade (30–39 years) with 1.92% (n = 1). The prevalence from the 7th decade of life (60 years and more) was nil (n = 0) (Table 6). A statistically significant difference was found only when the presence of the canal on the right side was compared to the age range of the subjects (p = 0.028). Greater prevalence of the CS was found for the right side particularly in the 1st, 2nd and 3rd decades of life (2.4%, 3.0% and 1.8%, respectively, Table 6) compared to the left.

The total average length (mean ± SD) of the CS was 19.59 ± 5.29 mm. On the right side the average length was 20.86 ± 5.11 mm, and 18.08 ± 5.18 mm on the left. Fig. 4 shows the lengths of the CS (right and left side) according to the sex of the subjects and Fig. 5 shows the lengths of the canal according to age range.

When the distance between the CS and the teeth in direct relation to its trajectory was measured, it was found that the second and third molar were the most involved teeth. Since the greatest percentages of prevalence were in the 2nd decade of life, the CS was mainly related to developing teeth (as shown in Figs. 1 and 3).

The average length measured from the CS to the developing third molar was 8.52 ± 2.18 mm, whereas to the developing second molar it was 6.36 ± 1.29 mm. By contrast, the average length measured from the CS to the fully developed third molar was 8.52 ± 2.18 mm, whereas to the fully developed second molar it was 6.36 ± 1.29 mm (Table 7).

Table 1
Intraclass correlation coefficient (ICC).

Association	ICC
Right side first measurement v/s Right side second measurement	0,999*
Left side first measurement v/s Left side second measurement	0,999*

*Perfect strength of agreement.

4. Discussion

From birth, the CS undergoes a gradual obliteration during the first year of life, [16] which explains its greater prevalence in children than in adults; however, Suazo et al.[4] disputes this idea. In their study they found that the prevalence of the bilateral CS in mandibles from 0 to 2 years of age was 100%. They also report that in adult mandibles (between 18 and 100 years), the prevalence of the CS is 42.6%, with 23.4% of the cases being unilateral. It is interesting to note that these authors record the presence of the CS at every age with a high concentration in the 4th and 5th decade of life. Further, in agreement with Bergmann et al.[17], the posterior portion of the CS is present in 60% to 73.7% of human fetuses, newborns and children up to 13 years of age. Our results, however, show a substantially lower prevalence (10.51%) than that reported by Suazo et al.[4] and Bergmann et al.[17], in addition to finding a greater presence of this canal in the 1st and 2nd decades of life, with the 4th decade having the lowest prevalence of all. The low prevalence found in our results can be attributed to the limitations of panoramic radiographs as overlapping structures. Our results also suggest that it is not always possible to find the CS bilaterally at any age.

Table 2
CS prevalence via digital panoramics x-rays.

Classification	Frequency	Percentage		Relative percentage[¶]
Absent	443	89,49		
Present on the right side*	19	3,84	10,51%	36,54
Present on the left side **	13	2,63		25,0
Bilateral ***	20	4,04		38,46
Total	495	100,0		

[*]Frequency and percentage of films in which the CS was alone on the right side, excluding the left and bilateral cases, [**]Frequency and percentage of films in which the CS was alone on the left side, excluding the right and bilateral cases, [***]Frequency and percentage of films in which the CS was bilateral, excluding cases of right and left side only, [¶]Calculated on the basis of the total cases (radiographs) in which was found the CS.

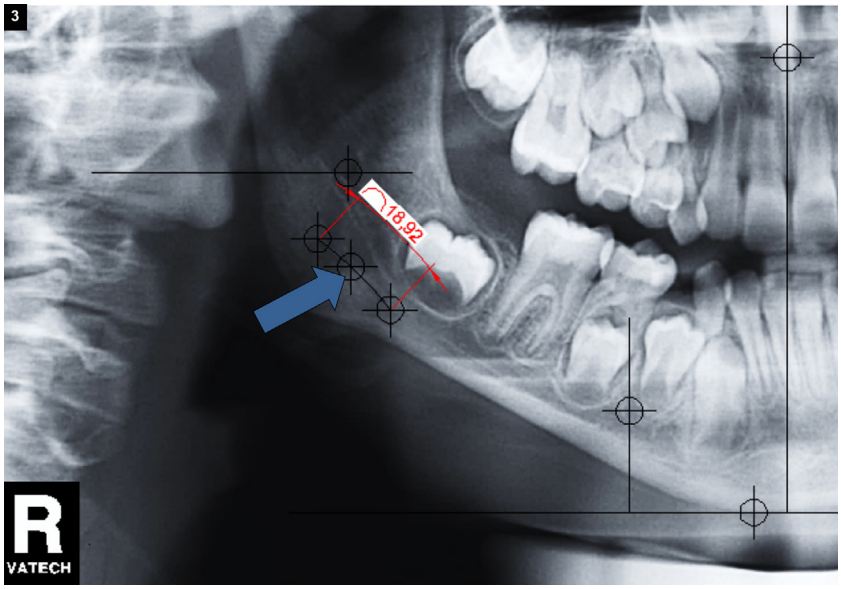

Fig. 3. Example of location and measurement through AutoCAD software.

Table 3
Contingency table of CS presence or absence by sex and mandibular side.

		Both sides		Total	Right side		Total	Left side		Total
		Present	Absent		Present	Absent		Present	Absent	
Man	Count	30	168	198	24	174	198	20	178	198
	% from the total	57,7	37,9	–	4,8	35,2	40,0	4,0	36,0	40,0
Woman	Count	22	275	297	15	282	297	13	284	297
	% from the total	42,3	62,1	–	3,0	57,0	60,0	2,6	57,4	60,0
Total	Count	52	443	495	39	456	495	33	462	495
	% from the total	100,0	100,0	–	7,8	92,2	100,0	6,6	93,4	100,0

Table 4
Statistical association between CS presence and length on the right side with the sex and age range.

Right side	Sex	Age	Right side
CS presence	p = 0,004[a]	p = 0,028[a]	p = 0,000[a]
CS length	p = 0,351	p = 0,391	

[a] Statistically significant differences.

The authors of this study did not find any publications making reference to the length and/or extension of the CS in the mandible. This study shows that the average length of the CS is nearly 2 cm (19.59 ± 5.29 mm), and that this never extends more anteriorly than the second molar.

The denomination of the canal of Serres must be modified according to the concepts of the current International Anatomical Terminology. In 2009, Suazo et al.[4] proposed a new term to refer to this canal, considering its orientation parallel to the mandibular canal. The name given at that time was the “paramandibular

Table 5
Statistical association between CS presence and length on the left side with the sex and age range.

Left side	Sex	Age	Left side
CS presence	p = 0,012[a]	p = 0,182	p = 0,000[a]
CS length	p = 0,393	p = 0,621	

[a] Statistically significant differences.

canal". However, this name does not taken into consideration that the CS is always below the mandibular canal in a superoinferior direction in the anatomical position. For these reasons for our working group the most correct term for the CS would be "inframandibular canal".

In this study we concluded that the CS is a prevalent structure in subjects under 20 years of age and its presence can be detected on a digital panoramic x-ray. Despite being a frequently used clinical exam, identification of the CS generally goes unnoticed or through ignorance or confusion is associated with other structures that correspond to variations of the mandibular canal. Identification of this canal and other structures through x-rays images is important in the planning of treatment that involves surgical interventions like dental implant placement and orthognathic surgery. The

Table 6
Contingency table that shows the CS presence and absence in the radiographs according to the age range and mandibular side.

Decade of life	Age range (years)		n° (radiographs)	CS presence	Right side			Left side		
				(radiographs)	Present	Absent	Total	Present	Absent	Total
1°	0–9	Count	88	15	12	76	88	10	78	88
		% from the total	17,78	28,85	2,4	15,4	17,8	2,0	15,8	17,8
2°	Oct-19	Count	146	20	15	131	146	11	135	146
		% from the total	29,49	38,46	3,0	26,5	29,5	2,2	27,3	29,5
3°	20–29	Count	100	11	9	91	100	7	93	100
		% from the total	20,20	21,15	1,8	18,4	20,2	1,4	18,8	20,2
4°	30–39	Count	42	1	1	41	42	0	42	42
		% from the total	8,49	1,92	0,2	8,3	8,5	0,0	8,5	8,5
5°	40–49	Count	43	3	0	43	43	3	40	43
		% from the total	8,69	5,77	0,0	8,7	8,7	0,6	8,1	8,7
6°	50–59	Count	46	2	2	44	46	2	44	46
		% from the total	9,29	3,85	0,4	8,9	9,3	0,4	8,9	9,3
7°	60 and more	Count	30	0	0	30	30	0	30	30
		% from the total	6,06	0,0	0,0	6,1	6,1	0,0	6,1	6,1
Total	–	Count	495	52	39	456	495	33	462	495
		% from the total	100,0	100,0	7,9	92,1	100,0	6,7	93,3	100,0

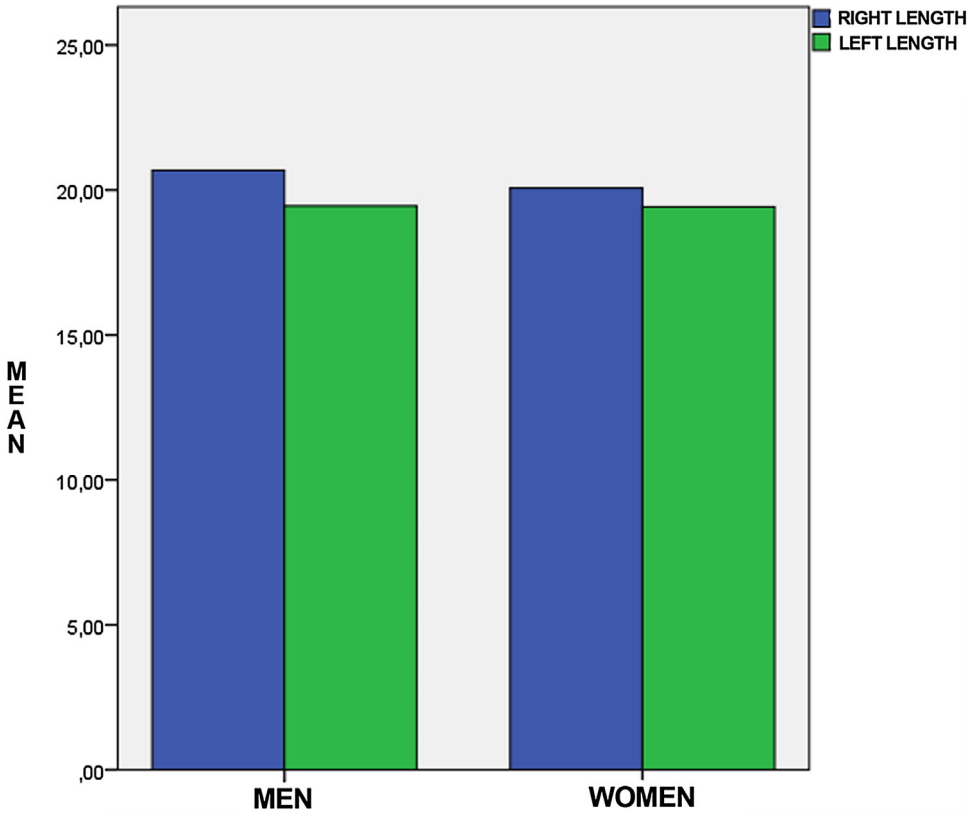

Fig. 4. Lengths of the CS (right and left side) according to the sex of the subjects.

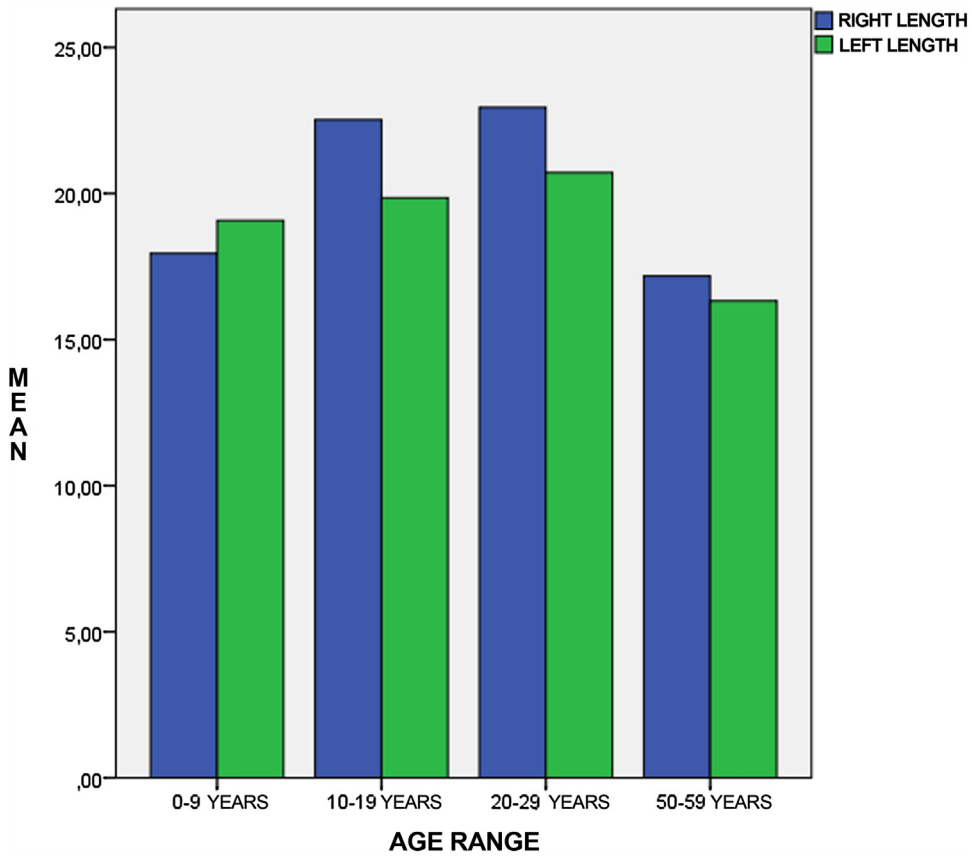

Fig. 5. Lengths of the CS (right and left side) according to the age range of the subjects.

Table 7
Average length from CS to the related teeth on their way.

Distance		Average length[a]
Developing teeth	Second molar	6,36 ± 1,29 mm
	Third molar	8,52 ± 2,18 mm
Mature teeth	Second molar	11,44 ± 2,89 mm
	Third molar	9,82 ± 1,87 mm

[a] Mean ± SD.

damage of vascular structures content in CS o mandibular canal it can cause serious complications such as bruises or bleeding.

Conflicts of interest

None.

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