

The Length of the Greater Palatine Canal in a Lebanese Population: a Radio-anatomical Study

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ABSTRACT

Objective: The aim of this study was to evaluate the length of the greater palatine canal in a Lebanese population using cone-beam computed tomography (CBCT) technology. **Material and methods:** In this study, we measured the length of 148 greater palatine canals in 74 CBCT images of Lebanese adult patients (38 females and 36 males). The data obtained was analyzed statistically to determine 1) if age is related to the length of the canal, 2) if the length of the left side tends to be systematically larger or smaller than the length of the right side, and 3) if the mean length of the canals in females is different than the one in males. **Results:** In a sagittal plane, the average length of the greater palatine canal was 30.62 (30.64 mm on the right and 30.60 mm on the left). **Conclusion:** Within the limits of this study, we concluded that in our sample in a Lebanese population, the length of the greater palatine canal does not significantly vary according to age, gender, and side.

Keywords: Cone-beam computed tomography; greater palatine canal; Lebanese population.

1. INTRODUCTION

The greater palatine canal (GPC) extends from the inferior part of the pterygopalatine fossa (PPF) to the hard palate.

The PPF contains, among other anatomic structures, the maxillary nerve. Therefore, injecting local anesthetic in the PPF via the GPC achieves deep anesthesia of all hemi-maxillary teeth with surrounding bone and soft tissue, sinus, the midface skin and the nasal cavity (1).

However, this technique is not without complications; thus, over or underestimated the GPC length can respectively induce a lack of anesthesia and diffusion of the anesthetic into undesirable regions such as the orbit, the cranial cavity, etc. (2).

Some of the complications related to the underestimation of the greater palatine canal length are listed in Table 1.

In this respect, knowledge of the length of the GPC is essential to safely perform the said technique. For that, taking advantage of the imaging technological advancement such as cone-beam computed tomography (CBCT) may provide more accurate assessments (1, 3).

The aim of this study was to evaluate the length of the GPC using CBCT data obtained from Lebanese adult population.

2. MATERIALS AND METHODS

In this retrospective study, CBCT radiographs of Lebanese adult patients were reviewed. Effectuated at a specialized maxillofacial imaging center for a variety of dental/oral indications (e.g., impacted teeth, sinus examination, implant planning, etc.), the CBCT scans were acquired using the PaX-Zenith3D[®] machine (Vatech, Co., Ltd., Yongin-Si, Republic of Korea). The technical parameters ranged between 70 to 100 kVp and 7 to 15 mA, with an exposure time of 20-35 s and medium to large FOVs according to the clinical case, in respect to the "As Low As Reasonably Achievable" (ALARA) principle.

The study inclusion criteria included:

- The minimum age of 18 years;
- The absence of pathological deformities in the maxilla.

Seventy-four CBCT images of 36 males and 38 females (a total of 148 GPCs) with an age ranging from 18 to 65 years met the inclusion criteria and

Complication	Cause of the complication
Diplopia	Anesthetizing the abducens nerve by diffusing the anesthetic into the orbit through the inferior orbital fissure
Ptosis	Blocking of the superior branch of the oculomotor nerve innervating the levator muscle of the upper eyelid
Persistent anesthesia	Traumatizing the maxillary nerve directly or indirectly by inducing the formation of local hematoma
Transient ophthalmoplegia	Anesthetizing the extraocular muscles of the eye
Temporary blindness	By the vasoconstrictor effect on the ophthalmic artery or by blocking of the optic nerve
Unconsciousness	Diffusion of the anesthetic via the foramen rotundum (intracranial injection)

Table 1. Some complications related to the underestimation of the greater palatine canal.

were included in this study.

The images were assessed by one radiologist having more than fifteen years of experience who measured the lengths of both the right and left GPCs in sagittal planes.

This procedure extended over four sessions of an average of twenty cases each. A period of ten days existed between the sessions.

To approximately calculate the measurement's error, they were repeated by the examiner fifteen days after the first readings without having in hands the initial results. In the case of any difference, the average of the two values was recorded.

In order to evaluate the canal length, the method suggested by Haward-Swirzinski et al. (1) was considered; it consists in taking the center of the vidian canal (located posteriorly in the PPF) as the superior aspect, and the greater palatine foramen on the inferior surface of the hard palate as the inferior one (Figure 1).

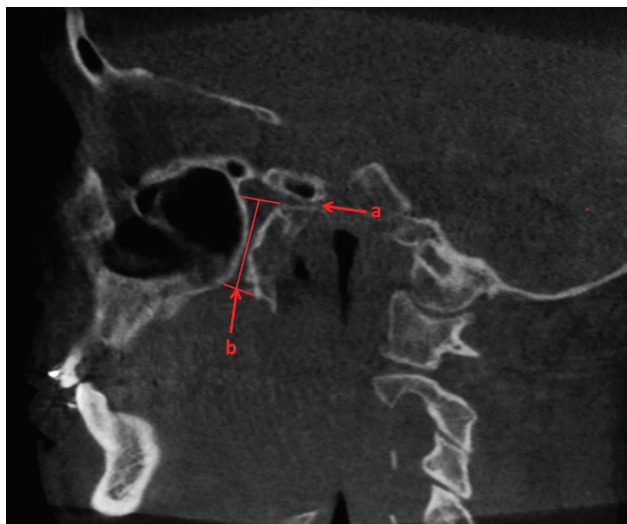


Figure 1. A CBCT sagittal cut at the level of the pterygopalatine fossa illustrating the method of determining the length of the greater palatine canal as considered by our study (at the level of the vidian canal); (a) the vidian canal and (b) the lower opening of the greater palatine canal corresponding to the greater palatine foramen.

We did not include in the measurements the thickness of the palatal mucosa.

The observation of the mean length of the canal was made by tilting the axial cut in order to see in the sagittal view:

- The vidian canal especially its opening in the center of the PPF;
- The path of GPC.

The GPC was then measured in millimeters from 2 marks placed at its upper and lower limits (Figure 1).

Descriptive statistics of age, gender, location (right/left), and lengths of the GPCs were calculated and analyzed for averages with standard deviations.

3. RESULTS

The length of the right and left GPCs was measured for 38 females and 36 males, aged 18 to 65 years old. The shortest canal in this study was 20.82 mm and the longest was 41.60 mm. Statistical analysis was done to determine a) if age is related to the length of the GPC, b) if the length of the left side tends to be systematically larger or smaller than the length of the right side, and c) if the mean length of the GPCs in females is different than the mean length of the ones in males. Microsoft Excel 2010 was used to generate plots, calculate simple linear regression parameters, and conduct t-tests. The statistical package R, version 3.2.3, lm function, was used for conducting multiple linear regressions.

* A scatter plot of age and length of the right GPC was developed, and linear regression was attempted to see if there is a linear relationship between the two variables. The R^2 value for the regression line was 0.00083 and the p-value for the line is 0.81, indicating there is no linear relationship, as can easily be seen in the scatter plot (Figure 2).

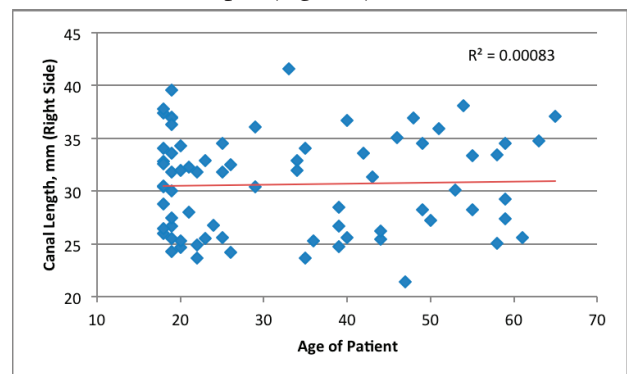


Figure 2. Scatter plot of age and length of the right GPC showing negative linear relationship between the two variables.

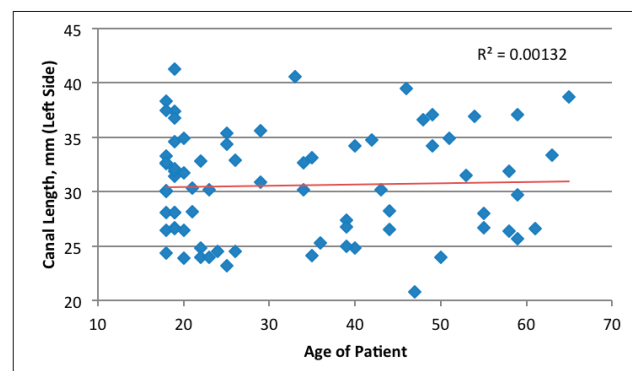


Figure 3. Scatter plot of age and length of the left GPC showing negative linear relationship between the two variables.

A similar trend line appears for the left side (Figure 3).

* The left and right side lengths were compared by conducting a paired t-test on the differences in length for each

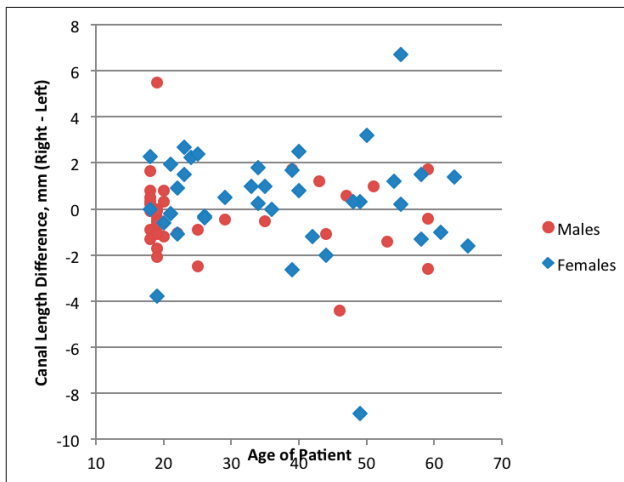


Figure 4. Scatter plot showing differences in length between the right and left canal; function of age and gender.

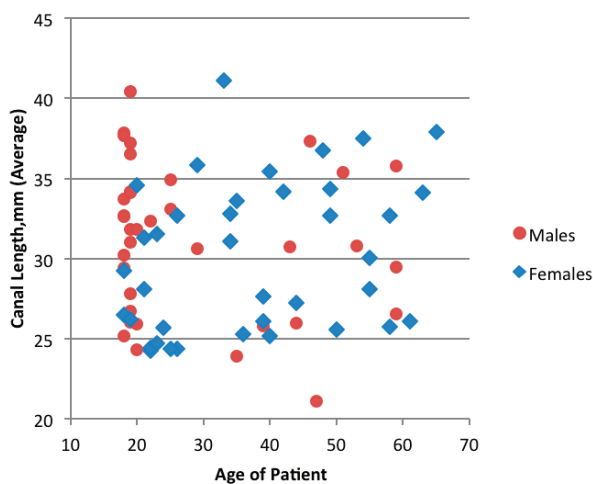


Figure 5. Scatter plot showing the average of the two canals for each patient, by age and gender.

person, with the null hypothesis that the mean difference is zero. The differences in length ranged from the left canal being 8.9 mm longer than the right canal, to the left canal being 6.7 mm shorter than the right canal. The mean difference for the 74 cases was 0.042 mm, with a standard deviation of 2.08 mm. The p-value for the t-test of differences was 0.86, indicating that the mean difference in canal lengths is indeed zero when using a significance level of 0.05. The scatter plot shows differences in length between the right and left canal, as a function of age and gender, and it is clear the differences are dispersed evenly about zero (Figure 4).

* The average length of the two GPCs for each patient was compared by gender, with the null hypothesis that the mean of the average lengths of the female canals is the same as the mean of the average lengths of the male canals. The average length of the female canals ranged from 24.3 mm to 41.1 mm, with a mean female length of 30.14 mm and a standard deviation of 4.67 mm. The average length of the male canals ranged from 21.1 mm to 40.5 mm, with a mean male length of 31.14 mm and a standard deviation of 4.69 mm. A t-test for two sample means was conducted on the length of the female canals compared to the length of the male canals. The p-value for the t-test was 0.36, indicating that the mean lengths of

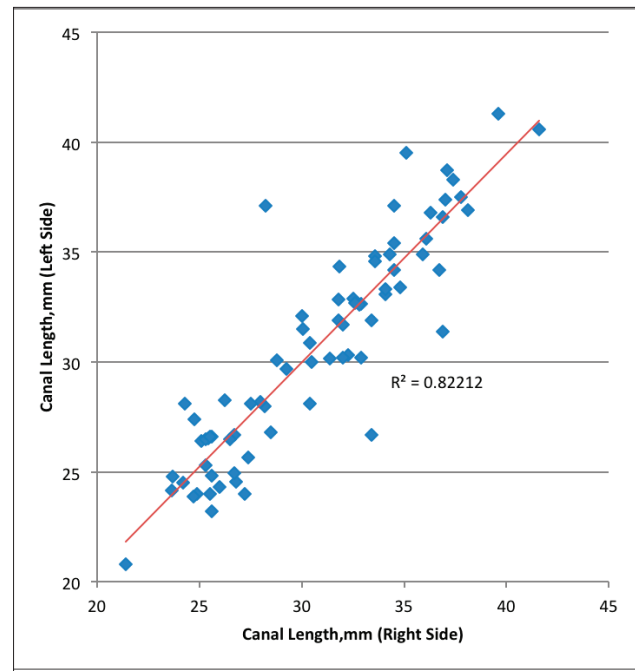


Figure 6. Scatter plot showing the lengths of each side of the canal for each patient

the female canals are the same as the mean lengths of the male canals when using a significance level of 0.05. The average of the two canals for each patient, by age and gender, are shown in the scatter plot (Figure 5).

To verify that age and gender were not related to the length of the GPC and that the right side is not systematically larger or smaller than the left side, multiple linear regression was attempted. The length of the left canal was considered to be the response variable, and the age, gender and length of the right canal were the predictor variables. When all two-way and three-way interaction terms were included, the model of the regression line was statistically significant with a p-value of <0.0001. In this model, only the length of the right canal was a statistically significant predictor of length of the left canal, with a p-value for the intercept of 0.813, and a 95% confidence interval for the ratio (slope) between the left and right canals of 0.50 to 1.33. After removing the interaction terms, the model was also statistically significant with a p-value of < 0.0001, a p-value for the intercept of 0.54, and only the length of the right canal as a statistically significant predictor, with a 95% confidence interval for the ratio (slope) of 0.84 to 1.04. Thus, multiple linear regressions confirm that neither age nor gender is related to the GPC and that there is no systematic difference between the lengths of the right and left GPCs in the subjects of this study. The lengths of each side of the canal for each patient are plotted against each other in the graph (Figure 6).

4. DISCUSSION

Anesthetizing the maxillary nerve via the GPC is a very useful technique. However, many complications may happen to result from poor knowledge of the region anatomy. It is well-known that the success of this technique depends primarily on the correct estimation of the GPC. For that, a good exploration prior to the maneuver is necessary. Therefore, a CBCT to evaluate the anatomy and the length of the

canal is indicated.

In many studies, the GPC was assessed in different ways and populations. Methathrathip et al. (4), and Urbano et al. (5) evaluate it on dry skulls, while others used the imaging technology like CT, CBCT, etc. (1, 6-10).

Concerning the canal length, it was either assessed as an isolated entity from the PPF (6, 10), or considered extending superiorly from different landmarks in the PPF such as the higher bony aspect of the PPF (11), the foramen rotundum (4), the sphenopalatine foramen (9), and the vidian canal (1, 7, 8) to the greater palatine foramen inferiorly.

In our study conducted on Lebanese adults using CBCT, we opted for the center of the vidian canal as the upper limit of the GPC. The average length was 30.62 mm ranging from 20.82 mm to 41.60 mm.

Our results were consistent with the ones of Haward-Swirzinski et al. (1), Tomaszewska et al. (7), and Sheikhi et al. (8), who adopted the same technique for the canal measurement and found respectively, 29 ± 3 mm (22 to 40 mm), 31.1 ± 2.9 mm (15 to 44 mm) and 31.82 ± 1.37 mm.

In our study, we did not find any statistical significance between the GPC length and the patients' age ($p = 0.81$), finding that corroborate the one of Sheikhi et al. ($p = 0.231$) who studied the canals in an Iranian population (8).

On the other hand, in our sample the connection GPC length - gender was statistically non significant ($p = 0.36$) which was not similar to what has been reported by Sheikhi et al. (8) ($p = 0.001$) and Tomaszewska et al. (7) ($p < 0.0001$). This difference may be due to ethnicity reason or caused by the limited size of our sample compared to others, especially the one of Tomaszewska et al. who analyzed the largest sample to date (1500 scans).

As for the relation canal length - canal location (right or left side) our negative results partially support the findings of Sheikhi et al. (8) who only observed statistically significant difference among the group of subjects older than forty-one year old.

Finally, our study aiming to evaluate the length of the GPC in a Lebanese population is not without limitations. Because of the limited number of canals assessed, definite conclusions must be delayed until future research validates our findings.

5. CONCLUSION

In order to have higher success rates by avoiding the complications associated with the technique of the maxillary nerve block through the GPC, a pre-operative CBCT scan for precise details on the canal anatomy and length appears to be essential.

• Conflict of interest: none declared.

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