Supramandibular Canal Portion Superior to the Fossa of the Submaxillary Gland: A Tomographic Evaluation of the Cross-Sectional Dimension in the Molar Region

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ABSTRACT

Purpose: Within the fossa of the submaxillary gland (FSG), there is a portion superior to the mandibular canal (SMCP) that can affect implant placement. Our study evaluated this specific portion's prevalence and its average dimensional difference between the first and the second molar regions in a dental implant population.

Materials and Methods: From 112 patients' mandibular cone beam computerized tomography scans, the SMCPs of the FSG's horizontal and vertical dimensions in the first and second molar positions on both sides were digitally measured.

Results: The SMCP of the FSG is larger in the second molar region than in the first molar region in >90% of cases. Average differences were 2.3 mm horizontally and 2.7 mm vertically. Gender difference and intraindividual's left/right variation were both clinically less significant in magnitude than the difference between the molar regions. Taking the 2-mm safety margin above the mandibular canal into consideration, the SMCP of the FSG remained high in prevalence.

Conclusions: The SMCP of the FSG may complicate implant placement more in the second molar region than in the first. Implant planning in the posterior mandibular molar regions should include a SMCP of the FSG evaluation using computer tomography especially in the second molar region.

KEY WORDS: dental anatomy, fossa, inferior alveolar nerve, lingual undercut, mandibular canal, mylohyoid ridge, submaxillary gland

INTRODUCTION

Within the fossa of the submaxillary gland (FSG), it is the portion superior to the mandibular canal (SMCP) that can affect implant placement. The size of this portion of the fossa depends on the mandibular canal's location relative to the mylohyoid ridge (Figure 1A). The further away the mandibular canal is from the mylohyoid ridge in a vertical dimension, the greater the amount of the fossa that is exposed to implant placement and thus increasing the potential for FSG perforation and for implant compromised implant placement.

As the location of the mandibular canal is not determinable through clinical palpation and the mylohyoid ridge cannot be seen on conventional peri-apical and panoramic radiographs, the dimension of the SMCP of the FSG can only be objectively evaluated using cross-sectional tomography, such as a computerized tomography (CT). The commonly used method of palpation of this region can only subjectively evaluate the depth of the fossa as a whole but cannot assess the SMCP of the FSG.

Although the SMCP is only visible with the use of tomography, often this technology is not readily

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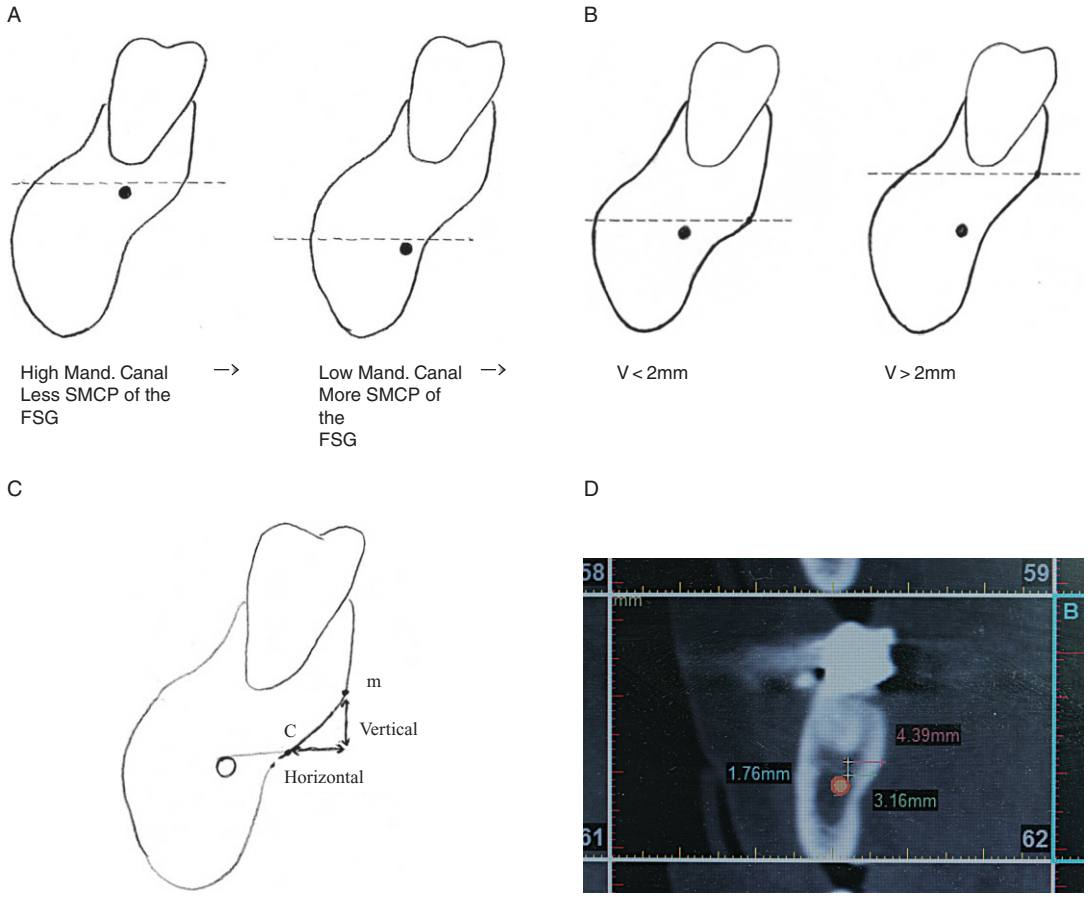

Figure 1 *A*, While the overall FSG may be similar in both cross-sectional slides above, the SMCP of the FSG may vary depending on the location of the mandibular canal, leaving differing levels of the FSG exposed to potential implant perforation. *B*, If the vertical dimension (V) is <2 mm, then the SMCP of the FSG would not affect implant placement because implant length, determined from conventional radiographs, would have been 2 mm away from the mandibular canal. *C*, A diagram showing both the horizontal and vertical dimensions of the SMCP of the FSG. *D*, A magnified cross-sectional view of a case in "Simplant View" with various digitally measured dimensions. FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

available at the initial treatment planning stage. In addition, some practitioners may choose to perform implant surgery in the posterior mandible without obtaining a tomograph. Therefore, it would be beneficial to know the prevalence and the average dimension of the SMCP of the FSG found in the population in order to bring awareness regarding this anatomy and to assist practitioners in making dental implant treatment decisions

Implant perforation into the FSG, below the SMCP and into the submandibular space, can potentially cause serious complications.[1,2] Postsurgical infection in this space may spread into the parapharyngeal space and ultimately the mediastinam.[4] Furthermore, perforated implant tip can cause long tern frictional irritation to nearby moving mucosa, muscles, and the tongue. Currently, one human clinical case report[5] and one computer simulation study[5] exist that pertain to implant perforation of the lingual cortical plate in the posterior mandibular region. The computer simulation study by Chan and colleagues[3] determined that the incidence of perforation in the first molar region was 1.1% to 1.2%. Although the perforation rate is low in the first molar region, the second molar region may potentially be different, thus having a different perforation risk. This study intends to evaluate the differences between the two molar regions. The findings will help evaluate the need for further studies in the implant perforation rate in the mandibular first and second molar regions. Furthermore, when facing a large SMCP of the FSG, practitioners may choose to avoid perforation by placing implants in compromised positions. Therefore, it is important to know the dimension and prevalence of the SMCP of the FSG in the molar regions in order to shed some light on the degree of complexity of the area.

In comparing the mandibular first and second molar regions' lingual bone, anatomy based on existing

studies demonstrated that the average cross-sectional bone inclination of the posterior mandible is more horizontal in the second molar region than in the first molar region.[6,7] Greater bone inclination may result in greater overall FSG dimension. However, the dimension of the implant relevant portion, which is the SMCP of the FSG, is dependent not just on the bone inclination but also on the amount of the FSG that lies superior to the mandibular canal (see Figure 1A). Therefore, greater bone inclination may indicate a larger overall undercut but does not necessarily equate to a larger SMCP of the FSG. Parnia and colleagues[8] measured the deepest horizontal dimension of the FSG to be greater than 2 mm in 80% of the case. This value is not tooth region specific and reflects no relationship to the mandibular canal. Chan and colleagues[9] measured the horizontal dimension of the FSG 2 mm above the mandibular canal but exclusively in the first molar area. The SMCP of the FSG's dimensional difference between the first and the second molar regions has yet to be evaluated.

A safety margin of at least 2 mm above the mandibular canal should be respected at both the implant treatment planning stage[10] and the surgical stage.[11] Understanding the SMCP of the FSG prevalence in the population, at the level of the 2-mm safety margin (see Figure 1B) and at various higher safety margins, would be of significant clinical benefit.

The objectives of this study are the following: (1) to measure and determine the average and the range of both the horizontal and vertical dimensions of the SMCP of the FSG at both the first and the second molar regions; (2) to compare the SMCP of the FSG differences between the two molar regions as well as between genders; (3) to evaluate the range of individual left–right differences; and (4) to assess the prevalence of cases in which the vertical dimension of the SMCP of the FSG exists at various safety margins above the mandibular canal.

MATERIALS AND METHODS

Sample Source, Size, and Selection

This retrospective study was performed using cone beam CT (CBCT) scans (iCAT Imaging Sciences International, Hatfield, PA, USA) taken in the Harvard School of Dental Medicine (HSDM) Division of Oral & Maxillofacial Radiology from May 1, 2006 to June 30, 2006. CBCT has a low distortion rate[12,13] and is clinically applicable for evaluating osseous dimensions.[14–18] CBCT scans were taken from patients who were referred by various private dental practices in the greater Boston area as well as patients within the HSDM system. This study received approval from Harvard Medical School Institutional Review Board (Study Number: M17977-101).

There were a total of 141 mandibular CBCT scans taken during this 2-month period. A total of 112 cases were included in this study. Exclusion criteria included the following: (1) nonidentifiable mylohyoid ridge and/or mandibular canal; (2) tooth region was not determinable; (3) presence of bone pathology; (4) staphne bone cyst; (5) radiographic evidence of mandibular premolar extraction with orthodontic treatment; and (6) osteoporosis.

Of the 112 cases, 55 were males and 57 were females. The mean age of the sample was 59.9 years old with a standard deviation of 10.3 years. The mean age of males and females was also both 59.9 years.

A board certified oral and maxillofacial radiologist (BDF) was responsible for identifying and labeling the mandibular canal for actual dental implant treatment planning purposes.

Measuring Methods

For each of the 112 cases, the SMCPs of the FSG's dimensions for both the first and the second molar regions on both the left and the right sides were measured. Simplant View 11.04 (Materialise Dental, Technologielan 15 3001, Leuven, Belgium) was used to view the images and the program's digital caliper was used to determine the horizontal and vertical distances between the mylohyoid ridge (m) and the point on the undercut that was located at the same vertical depth as the superior border of the mandibular canal (c) (see Figure 1C). All molar sites, whether dentate or edentulous, were measured. This Simplant software allowed each cross section to be measured at 0.4-mm resolution and viewed at ×2 to 4 magnification (see Figure 1D).

Statistical Analyses

STATA 8.2 statistical software (StataCorp LP, College Station, TX, USA) was used to analyze the data. In order to test for statistical significance, a two-sided *t*-test was used and p was set at $<.05$.

RESULTS

The First Molar Region versus the Second Molar Region

The SMCP of the FSG's vertical dimension in 92.9% (208/224) of the sites and its horizontal dimension in 97.8% (219/224) of the sites were larger in the second molar region than in the first molar region (Table 1). The second molar region's SMCP of the FSG was larger by an average of 2.3 mm horizontally and 2.7 mm vertically irrespective of gender. With respect to gender, male's average SMC of the FSG dimension was slightly larger than the overall combined average by 0.15 mm horizontally and 0.26 mm vertically. Female's average SMCP of the FSG dimension was slightly smaller than the overall combined average by the same magnitude. Both the horizontal and vertical differences were statistically significant at $p < .05$ (Table 2).

Male versus Female

On the average, the males had a larger SMCP of the FSG than females by <1 mm horizontally and 1 to 2 mm vertically. The differences were statistically significant at $p < .05$ (Table 3).

Dentate Regions versus Edentulous Regions

SMCP of the FSG in the dentate patient was modestly larger in the horizontal and vertical dimensions compared with the edentulous mandible in both first and second molar regions, ranging from 0.36 to 1.03 mm. The differences between the first molar region's horizontal dimension and the second molar region's vertical dimension were statistically significant at $p < .05$. However, gender may be a confounder in this study subject pool as edentulous mandibular molar sites were found more often in females than in males (Table 4).

Individual Left–Right Variation

The intraindividual's SMCP of the FSG left–right variation averaged 1.1 to 1.3 mm vertically and 0.7 to 1 mm horizontally for both molar regions (Table 5).

Prevalence of SMCP of the FSG at Various Safety Margins from the Mandibular Canal

When the 2-mm safety margin above the mandibular canal was taken into consideration, the SMCP of the FSG is still present in 85% of first molars in males and 80% in females. This was also true for 100% of males and 96% of females at the second molar site (Table 6).

In both genders, as safety margin increases, the SMCP of the FSG decrease in prevalence is more rapid in the first molar region than in the second molar region. For instance, at a 5-mm safety margin, second molar region's SMCP of the FSG prevalence decreased to 44% for males and 22% for females, while the first molar region remained high at 87% for males and 68% for females (see Table 6). It was determined that females are less likely to have SMCP of the FSG than males at all safety margin levels.

DISCUSSION

The SMCP of the FSG's Differences between the Molar Regions

In mandibular molar implant sites with large SMCP of the FSG, implant osteotomy preparation following the ideal implant position may face higher lingual perforation risk and more anatomic limitations. This study showed that the SMCP of the FSG in the population is on average 2 mm greater both vertically and horizontally in the second molar region than in the first molar region. Greater than 90% of the population have larger SMCP of the FSG in the second molar region than in the first molar region. Therefore, it may be a general rule rather than an exception that the SMCP of the FSG's dimension may complicate implant placement in the

TABLE 1 Percentage of Sites Where the SMCP of the FSG Dimension Is Larger in the Second Molar Region Than in the First Molar Region

Dimension	Male	Female	Total (Male + Female)
Horizontal	95.5% (105/110)	90.4% (103/114)	92.9% (208/224)
Vertical	98.2% (108/110)	97.4% (111/114)	97.8% (219/224)

FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

TABLE 2 Average Horizontal and Vertical Dimensions of SMCP of the FSG in the First and Second Molar Regions

Gender		First Molar			Second Molar			Second Molar–First Molar Difference	*t*-Test
		Mean ± 95% CI	Standard Deviation	*n*	Mean ± 95% CI	Standard Deviation	*n*		
Male	Horizontal	2.37 ± 0.31 mm	1.62 mm	110	4.78 ± 0.29 mm	1.51 mm	110	+2.41 mm	11.4134
Male	Vertical	4.85 ± 0.50 mm	1.84 mm	110	7.83 ± 0.42 mm	2.19 mm	110	+2.98 mm	10.9267
Female	Horizontal	1.81 ± 0.17 mm	0.92 mm	114	3.92 ± 0.22 mm	1.21 mm	114	+2.11 mm	14.8211
Female	Vertical	3.65 ± 0.34 mm	1.84 mm	114	6.12 ± 0.42 mm	2.29 mm	114	+2.47 mm	10.7822
Male + female	Horizontal	2.08 ± 0.18 mm	1.33 mm	224	4.34 ± 0.19 mm	2.34 mm	224	+2.26 mm	17.2630
Male + female	Vertical	4.24 ± 2.33 mm	1.43 mm	224	6.96 ± 0.31 mm	2.39 mm	224	+2.72 mm	12.1440

CI = confidence interval; FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

TABLE 3 Average Horizontal and Vertical Dimensions of SMCP of the FSG in Male and Female

Tooth Region		Male			Female			Male–Female Difference	*t*-Test
		Mean ± 95% CI	Standard Deviation	*n*	Mean ± 95% CI	Standard Deviation	*n*		
First molar	Horizontal	2.37 ± 0.31 mm	1.62 mm	110	1.81 ± 0.17 mm	0.92 mm	114	+0.56 mm	3.2810
	Vertical	4.85 ± 0.50 mm	1.84 mm	110	3.65 ± 0.34 mm	1.84 mm	114	+1.20 mm	4.0215
Second molar	Horizontal	4.78 ± 0.29 mm	1.51 mm	110	3.92 ± 0.22 mm	1.21 mm	114	+0.86 mm	4.8087
	Vertical	7.83 ± 0.42 mm	2.19 mm	110	6.12 ± 0.42 mm	2.29 mm	114	+1.71 mm	5.7891

CI = confidence interval; FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

TABLE 4 Average Horizontal and Vertical Dimensions of SMCP of the FSG in Dentate versus Edentulous Sites

Tooth Region		Dentate Sites				Edentulous Sites				Dentate-Edentulous Difference	*t*-Test
		Mean ± 95% CI	Standard Deviation	*n*	Male : Female	Mean ± 95% CI	Standard Deviation	*n*	Male : Female		
First Molar	Horizontal	2.43 ± 0.28 mm	1.40 mm	99	54:45	1.81 ± 0.22 mm	1.22 mm	125	56:69	+0.62 mm	3.5640
	Vertical	4.46 ± 0.47 mm	2.36 mm	99	54:45	4.07 ± 0.41 mm	2.31 mm	125	56:69	+0.39 mm	1.2390
Second Molar	Horizontal	4.48 ± 0.21 mm	1.24 mm	140	74:66	4.12 ± 0.37 mm	1.69 mm	84	36:48	+0.36 mm	1.8454
	Vertical	7.34 ± 0.40 mm	2.34 mm	140	74:66	6.31 ± 0.51 mm	2.35 mm	84	36:48	+1.03 mm	3.1953

CI = confidence interval; FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

posterior mandible more in the second molar region than in the first molar region. Careful surgical and prosthetic planning through appropriate implant fixture dimensions and abutment choice combined with calculated placement position and angulation may assist in accommodating large SMCP of the FSG. In extreme cases, first molar occlusion may be the occlusal scheme of choice.

The SMCP of the FSG's Gender Differences

In both the vertical and the horizontal dimensions, gender difference was in the range of 0.5 to 0.9 mm horizontally and 1.2 to 1.7 mm vertically. These ranges were smaller than the dimensional differences between the two molar regions, which were 2.3 mm horizontally and 2.7 mm vertically. This may indicate that both the differences in perforation risk and in the level of anatomical limitation between the genders may be less compared with the differences between the molar regions. Further investigation may provide more evidence regarding the relationship between the gender and the SMCP of the FSG-related risks/limitation.

Study of Parnia and colleagues[8] found no statistical significance between the genders in the value for the greatest horizontal depth of the FSG. This present study was able to demonstrate that region-specific SMCPs of the FSG's gender differences were statistically significant at $p < .05$.

The SMCP of the FSG's Average Left–Right Variation within Individual Subjects

For both molar regions, the average intraindividual left–right variation was determined to be 1.1 to 1.3 mm vertically and 0.7 to 1 mm horizontally. This showed that the SMCP of the FSG dimensional asymmetry within each individual may need to be taken into consideration during treatment planning for dental implant therapy. SMCP of the FSG's dimensional information obtained from CBCT on one side of the mandible may not be transferable to the other side within the same patient. Successful avoidance of FSG perforation on one side does not necessarily translate to a similar outcome on the contralateral side.

FSG as a Constant Region Irrespective of Tooth Loss

The FSG lies in the basal portion of the mandible. Its dimension is believed to remain relatively constant

TABLE 5 Average Intraindividual's Difference between Left and Right Sides

Tooth Region		Mean ± 95% CI	Standard Deviation	*n*
First molar	Horizontal	0.75 ± 0.14 mm	0.75 mm	112
	Vertical	1.30 ± 0.21 mm	1.12 mm	112
Second molar	Horizontal	0.94 ± 0.16 mm	0.85 mm	112
	Vertical	1.13 ± 0.22 mm	1.17 mm	112

CI = confidence interval.

throughout life[19–21] and not be affected by tooth loss.[19,21] The validity of our study is based on this generally accepted assumption. Attempt in our study to investigate the effect of tooth loss on the SMCP of the FSG's dimension was complicated because gender was determined to be a confounding factor.

The Safety Margin Above the Mandibular Canal

At the 2-mm vertical safety margin above the mandibular canal, the SMCP of the FSG remains prevalent in the majority of the cases studied, ranging from 80% in female's first molar region to 100% in male's second molar region. This could be interpreted to mean that in the majority of the population, respecting the 2-mm safety margin above the mandibular canal does little to eliminate the presence of the SMCP of the FSG.

It is interesting to note that the first molar region in females has a lower percentage of SMC of the FSG positive cases than males and other mandibular regions. For instance, at 5- and 6-mm safety margins, the SMCP of the FSG prevalence was only 22% and 10%, respectively. However, it is also likely that females on average may have a smaller crest to mandibular canal height.

Increasing the safety margin will reduce the prevalence of the SMCP of the FSG less so in the second molar region compared with the first molar region. This could mean that avoiding the SMCP of the FSG in the population, by shortening the implant length, is less probable in the second molar region than in the first molar region.

It has been demonstrated that the simulated implant perforation rate through the mandibular lingual cortical plate is 1.1% to 1.2% in the first molar region.[2] Based on additional information elucidated from this study, a similar type of study investigating the perforation rate in the second molar region is advised.

SMCP of the FSG's Prevalence as a Possible Limitation on Implant Size Choices

Studies have demonstrated that additional anatomical information from a cross-sectional CT views may alter the chosen implant length that was previously selected from the use of conventional radiographs.[22,23] Schropp and colleagues[22] demonstrated that a discrepancy exists between the implant length determined from

TABLE 6 The Percentage of Sites Where SMCP of the FSG Exists at Various Safety Margins above the Mandibular Canal in the First and Second Molar Regions

Safety Margin Level above the Mandibular Canal	First Molar		Second Molar	
	Male	Female	Male	Female
2 mm	85% (94/110)	80% (91/114)	100% (110/110)	96% (109/114)
3 mm	74% (81/110)	61% (70/114)	99% (109/110)	92% (105/114)
4 mm	61% (67/110)	43% (49/114)	98% (108/110)	84% (96/114)
5 mm	44% (58/110)	22% (25/114)	87% (96/110)	68% (78/114)
6 mm	33% (36/110)	10% (11/114)	78% (86/110)	48% (55/114)

FSG = fossa of the submaxillary gland; SMCP = portion superior to the mandibular canal.

panoramic radiographs and the actual length of the implant that was placed. Our study has shown that the FSG exists above the mandibular canal in the majority of implant cases including those where safety margins greater than 2 mm are considered. It is important for practitioners to recognize that implant length determination in the mandibular molar region, particularly the second molar region, should be determined not only based on the crest-mandibular canal measurement but also on the SMCP of the FSG. It is advisable to obtain a CT scan in these areas rather than relying on panoramic or peri-apical radiographs and/or digital palpation of this region.

CONCLUSION

This study demonstrated that in this implant population, the mandibular second molar region has a larger SMCP of the FSG than the first molar region. The average dimensional differences between the two molar regions were more clinically significant than both the average intraindividual left–right variation and the average difference between the genders. A majority of the population is more likely to have a SMCP of the FSG in both molar regions. This remained true even at the 2-mm safety margin above the mandibular canal. Increasing the safety margin, for both molar regions, is unlikely to sufficiently reduce the prevalence of the SMCP of the FSG in this population particularly in the second molar region.

The clinical implications of these findings will educate practitioners in recognizing that implant placement in the mandibular second molar region is more likely to need more careful surgical and prosthetic accommodation than the first molar region. The prevalence and the size range of the SMCP of the FSG found in the population should cause practitioners to rethink the choice of tomography as opposed to conventional radiographs when placing implants in the posterior mandible particularly in the second molar area. Only tomography is capable of analyzing the SMCP of the FSG in cross section and thus illuminating the anatomy of this region. Further studies are needed to evaluate that the extent tomography influences implant size, position, and angulation choices particularly in the posterior mandible. Studies evaluating the relationship between the SMCP of the FSG size and implant perforation risk are also advised.

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