CLINICAL ORAL IMPLANTS RESEARCH

Güliz N. Güncü
Yağmur D. Yıldırım
Hasan Güney Yılmaz
Pablo Galindo-Moreno
Miguel Velasco-Torres
Khalid Al-Hezaimi
Reema Al-Shawaf
Erdem Karabulut
Hom-Lay Wang
Tolga F. Tözüm

Is there a gender difference in anatomic features of incisive canal and maxillary environmental bone?

Authors' affiliations:
Güliz N. Güncü, Yağmur D. Yıldırım, Tolga F. Tözüm, Department of Periodontology, Faculty of Dentistry, Hacettepe University, Ankara, Turkey
Hasan Güney Yılmaz, Department of Periodontology, Faculty of Dentistry, Near East University, Mersin, Turkey
Pablo Galindo-Moreno, Miguel Velasco-Torres, Department of Oral Surgery & Implant Dentistry, University of Granada, Granada, Spain and Department of Periodontics & Oral Medicine, School of Dentistry, The University of Michigan, Ann Arbor, MI, USA
Reema Al-Shawaf, Diagnostic Sciences Department, College of Dentistry, King Saud University, Riyadh, Saudi Arabia
Khalid Al-Hezaimi, Hom-Lay Wang, Eng.A.B. Research Chair for Growth Factors and Bone Regeneration, Division of Periodontics, College of Dentistry, Riyadh, Saudi Arabia
Erdem Karabulut, Department of Biostatistics, Faculty of Medicine, Hacettepe University, Ankara, Turkey
Hom-Lay Wang, Department of Periodontics & Oral Medicine, School of Dentistry, The University of Michigan, Ann Arbor, MI, USA

Corresponding author:
Dr *Tolga F. Tözüm*
Department of Periodontology
Faculty of Dentistry
Hacettepe University
3rd Floor, Sihhiye, 06100
Ankara
Turkey
Tel.: +90 312 305 2237
Fax: +90 312 310 4440
e-mail: ttozum@hacettepe.edu.tr

Date:
Accepted 8 April 2012

To cite this article:
Güncü GN, Yıldırım YD, Yılmaz HG, Galindo-Moreno P, Velasco-Torres M, Al-Hezaimi K, Al-Shawaf R, Karabulut E, Wang H-L, Tözüm TF. Is there a gender difference in anatomic features of incisive canal and maxillary environmental bone?.
Clin. Oral Impl. Res. **24,** 2013, 1023–1026
doi: 10.1111/j.1600-0501.2012.02493.x

Key words: cone beam computed tomography, gender, humans, implant, maxilla, spiral computed tomography

Abstract

Objectives: The effect of gender on anatomic structures and various body systems were illustrated in the literature. The purpose of this study was to identify the influence of gender and tooth loss on incisive canal characteristics and buccal bone dimensions in the anterior maxilla.

Materials and methods: Computed tomographies (CTs) of 417 male and 516 female patients in four dental clinics were included in this study. The diameter and the length of the incisive canal; width and the length of the bone anterior to the canal; palatal bone length, root length, and root width of the central incisor teeth were measured and recorded from CT sections.

Results: Mean incisive canal length was 11.96 ± 2.73 mm and 10.39 ± 2.47 mm in men and women, respectively, ($P < 0.05$). In men, mean canal diameter was 2.79 ± 0.94 mm whereas in women it was 2.43 ± 0.85 mm and this difference was statistically significant ($P < 0.05$). Men had significant higher buccal bone dimensions (length and width of the bone anterior to the canal) than women. Absence of teeth in the anterior maxilla decreased incisive canal length and buccal bone dimensions; however, canal diameter remain unchanged.

Conclusions: Present results suggested a gender related differences in anatomic features of incisive canal and surrounding buccal bone. In addition, crestal canal diameter, buccal bone length, and thickness parameters might be different in distinct countries.

Anterior segments of the jaws in maxillary and mandibular locations are often considered as safer areas when compared with posterior jaws during surgeries (Artzi et al. 2000; Jacobs et al. 2007). Incisive canal (IC), located at the midline, posterior to the central incisor teeth, is an important anatomic structure of anterior maxillary area. However, the anatomic characteristics of this area are poorly documented. Hence, it is important to know the anatomic features in this area when performing surgeries (e.g., implant, bone augmentation, apicoectomy). Nasopalatine nerve and terminal branch of the nasopalatine artery pass through this canal (Song et al. 2009). IC has two to four nasopalatine foramina and one incisive foramen.

Innovations in imaging systems and increased usage of preoperative CT evaluation have allowed us to have a more accurate and close look at these anatomic structures and pathologies (Faitaroni et al. 2011; Guncu et al. 2011). Mean incisive canal length obtained from CT studies ranged from 8 to 12 mm (Mraiwa et al. 2004; Mardinger et al. 2008; Liang et al. 2009; Song et al. 2009; Bornstein et al. 2010). The narrowest canal diameter was 1.1 mm and the widest was 6.7 mm (Song et al. 2009). In addition, there are variously defined morphological types of the canal in the literature (Mardinger et al. 2008; Song et al. 2009; Bornstein et al. 2010). According to the presence or absence of teeth in the anterior maxilla, dimensional changes

of anterior jaw bones and incisive canal were reported (Mardinger et al. 2008; Liang et al. 2009). Liang et al.(2009) examined 60 dentate and 60 edentulous CT scans and found longer canals in dentate group; however, no change in canal diameter. Affect of gender differences on anatomic structures were also reported in Liang's study (2009). According to the results, men had longer and wider canals (Liang et al. 2009). Moreover, Bornstein et al. (2010) reported the influence of gender and dental status on buccal bone dimensions and incisive canal. Kovisto et al. (2011) investigated the proximity of mandibular canal to the teeth apex and the mesial root of the second molar was found closer to the nerve in female patients compared with male patients.

Our group has previously documented the anatomic features of incisive canal and environmental bone in CT scans of human subjects (Tozum et al. 2012). Canal diameter, canal length and shape, width of buccal and palatal bone, root width and the length of bone between apex of anterior tooth, and nasal floor were examined in that study. Results suggested that there were differences in some parameters between men and women. Evaluating all these parameters together in a high numbered population including multicenter may reveal the distinct impact of gender to the features of incisive canal and maxillary environmental bone. On the basis of the results of our previous study and literature, we aimed to identify the influence of tooth loss and gender on canal characteristics and buccal bone dimensions in the anterior maxilla in the second part of our multicenters study.

Materials and methods

Computed tomographies of 417 male and 516 female patients in four dental clinics: Turkey (171 CTs), Spain (310 CTs), Saudi Arabia (133 CTs), and Cyprus (319 CTs) were included in this study. A total of 725 of patients were dentate and 208 were edentulous. All the measurements were performed by one calibrated examiner (YDY, MVT, RAS, HGY) at each center on axial CT scans, using software programs. Spiral (Siemens AR-SP 40; Siemens, Munich, Germany) and cone beam (Imaging Sciences International, Hatfield, PA, USA) CT scans were used. A detailed research protocol was discussed and agreed before initiation of the study. Measurements were determined on schematic diagrams and detailed start and end points of the measurements were clarified between calibrated investigators. Intra and inter observer agreement for each measurement was in substantial agreement in each center. The selected landmarks; the diameter and the length of the incisive canal (crestal, middle, and apical); width and the length of the bone anterior to the canal; palatal bone length, root length, and root width of the central incisor teeth were measured according to protocol (Mardinger et al. 2008; Bornstein et al. 2010; Tozum et al. 2012). The anatomic variations of the canal were examined on axial sections and classified into four groups (Mardinger et al. 2008): (1) Cylindrical, (2) Banana-like, (3) Hourglass-like, and (4) Funnel-like. Low quality CT images and CT's of patients with evident nasopalatine pathology were excluded from the study.

Statistical analysis

All statistical data analysis was performed in one center (Turkey) using SPSS 11.5.0 software for Windows (SPSS, Chicago, IL, USA). Three-way ANCOVA (country, gender, dentate, and three independent variables) were performed to compare data between dentate and edentate as well as male vs. female patients. When the difference was detected, pairwise comparisons were performed using Bonferroni test. If interaction terms were found statistically significant, subgroups analyses were performed using independent samples *t*-test or one-way ANOVA.

Results

No statistically significant difference was detected between the mean age of 312 male and 413 female dentate patients (Table 1). However, incisive canal length and diameter of dentate subjects differed according to gender. Mean values showed that men had longer and wider canals in dentate subjects ($P < 0.0001$). Buccal bone dimensions (length and width of bone anterior to the canal) were significantly different between genders, where men had greater values than women ($P < 0.0001$) (Table 1). The roots of central incisor teeth of men were thicker than women as well. When these parameters were examined in edentulous subjects similar results were also found (Table 2). Mean age was also similar in edentulous group, as well as dentate patients. Length, width of the canal, and buccal bone thickness were greater in male subjects compared with female subjects ($P = 0.001$, $P = 0.025$, $P = 0.001$, respectively) (Table 2).

Edentulous male and female subjects were older than dentate men and women, as expected ($P < 0.0001$). Absence of teeth in the anterior maxilla caused a decrease at incisive canal length and buccal bone dimensions; however, canal diameter was not changed in men ($P < 0.0001$) (Table 3). Similar results were also observed for women (Table 4). Edentulous women had shorter incisive canals ($P = 0.004$). Buccal bone width and length were smaller in edentulous women than dentate women ($P < 0.0001$) In

Table 1. **The differences in examined parameters in male and female subjects in dentate patients**

		Men (n = 312) Mean ± SD	Women (n = 413) Mean ± SD	P
Age (mm)		41.37 ± 15.80	40.14 ± 15.58	0.295
Canal length (mm)		11.96 ± 2.73	10.39 ± 2.47	$P < 0.0001$
Buccal length (mm)		20.56 ± 3.36	19.52 ± 3.18	$P < 0.0001$
Palatal length (mm)		11.58 ± 2.6	10.63 ± 2.79	$P < 0.0001$
Root length (mm)		13.17 ± 1.76	12.25 ± 1.59	$P < 0.0001$
Canal diameter (mm)	Crestal	3.22 ± 1.05	2.67 ± 0.89	$P < 0.0001$
	Medial	2.26 ± 0.97	1.95 ± 0.87	$P < 0.0001$
	Apical	2.91 ± 1.40	2.67 ± 1.40	0.027
	Mean	2.79 ± 0.94	2.43 ± 0.85	$P < 0.0001$
Bone thickness anterior to the canal (mm)	Crestal	6.32 ± 1.13	5.86 ± 1.28	$P < 0.0001$
	Medial	7.22 ± 1.56	6.40 ± 1.39	$P < 0.0001$
	Apical	9.84 ± 2.58	8.92 ± 2.40	$P < 0.0001$
	Mean	7.80 ± 1.37	7.06 ± 1.37	$P < 0.0001$
Palatal bone thickness (mm)	Crestal	2.52 ± 0.85	2.06 ± 0.81	$P < 0.0001$
	Medial	5.37 ± 1.35	4.47 ± 1.24	$P < 0.0001$
	Apical	8.24 ± 2.16	7.00 ± 2.02	$P < 0.0001$
	Mean	5.38 ± 1.27	4.52 ± 1.18	$P < 0.0001$
Root width (mm)	Crestal	6.31 ± 0.63	5.95 ± 0.66	$P < 0.0001$
	Medial	5.14 ± 0.61	4.88 ± 0.59	$P < 0.0001$
	Apical	2.19 ± 0.57	1.97 ± 0.67	$P < 0.0001$
	Mean	4.55 ± 0.44	4.27 ± 0.42	$P < 0.0001$

$P < 0.05$ is statistically significant.

Table 2. **The differences in examined parameters of male and female subjects in edentate patients**

		Men (n = 105) Mean ± SD	*Women* (n = 103) Mean ± SD	*P*
Age (mm)		53.18 ± 12.83	56.18 ± 13.02	0.095
Canal length (mm)		10.70 ± 2.53	9.62 ± 2.31	0.001
Buccal length (mm)		17.03 ± 3.78	15.72 ± 3.46	0.001
Palatal length (mm)		11.53 ± 2.94	10.25 ± 2.46	0.001
Canal diameter (mm)	Crestal	3.17 ± 1.12	2.88 ± 0.96	0.048
	Medial	2.09 ± 0.93	1.98 ± 0.83	0.372
	Apical	2.91 ± 1.36	2.54 ± 1.37	0.053
	Mean	2.76 ± 1.01	2.47 ± 0.85	0.025
Bone thickness anterior to the canal (mm)	Crestal	4.43 ± 1.62	3.76 ± 1.57	0.003
	Medial	6.77 ± 1.62	6.10 ± 1.80	0.005
	Apical	9.08 ± 2.51	8.43 ± 2.04	0.041
	Mean	6.77 ± 1.50	6.10 ± 1.40	0.001
Palatal bone thickness (mm)	Crestal	2.11 ± 0.80	1.80 ± 0.59	0.002
	Medial	4.91 ± 1.40	4.25 ± 1.25	0.001
	Apical	7.11 ± 2.07	6.53 ± 1.96	0.044
	Mean	4.71 ± 1.25	4.18 ± 1.16	0.002

$P < 0.05$ is statistically significant.

contrast, there is no significant difference between canal diameter of edentulous and dentate women ($P < 0.05$) (Table 4).

In the whole study population, including men and women, cylindrical canal shape was the most prevalent shape, whereas banana-like was the least in both gender. Women have 45.54% cylindrical, 26.55% funnel-like, 16.47% hourglass-like, and 11.44% banana-like canals. These parameters were 34.77%, 29.02%, 21.58%, and 14.63%, respectively, for men. The percentages of canal morphologies of incisive canal in dentate and edentate subjects according to gender were also presented in Table 5.

According to three-way ANCOVA analysis (country, gender, and dentition status) interactions for buccal bone length, crestal canal diameter, and crestal buccal bone thickness was detected ($P = 0.001$, $P = 0.017$, $P = 0.005$, respectively). Country and dentition status interaction was found for buccal bone length. Buccal bone length was higher in Arabia in dentate patients than other countries ($P < 0.05$). Buccal bone length in edantate patients in Turkey was found higher than in Spain and Cyprus ($P < 0.05$).

In addition, country and gender interactions were found for crestal canal diameter for women. Crestal canal diameter of women subjects in Cyprus and Spain was higher than other countries.

Interactions were found for all three independent variables (country, gender, and dentition status) for crestal buccal bone thickness. Gender differences were detected in edantate subjects in Spain whereas it was detected in dentate subjects in Arabia and Cyprus. Crestal buccal bone thickness did not differ for gender and dentition in Turkey. On the other hand, crestal buccal bone thickness of both genders in all countries differed according to dentition status ($P < 0.05$).

Discussion

Effect of gender and presence of teeth on anatomic structures (such as incisive canal at maxillary region, mandibular canal) have been reported in literature (Mraiwa et al. 2004; Mardinger et al. 2008; Liang et al. 2009; Song et al. 2009; Bornstein et al. 2010; Kovisto et al. 2011; Tozum et al. 2012). Our data showed gender and presence of teeth influenced the incisive canal dimensions and bone dimensions anterior to this canal. When dentate subjects were classified based upon gender, men had greater canal and bone dimensions. Edentulous subjects showed the

Table 3. **Comparative statistical analysis of dentate and edentate male subjects**

		Dentate (n = 312) Mean ± SD	Edentate (n = 105) Mean ± SD	*P*
Age (mm)		41.37 ± 15.80	53.18 ± 12.82	<0.0001
Canal length (mm)		11.96 ± 2.73	10.70 ± 2.53	<0.0001
Buccal length (mm)		20.56 ± 3.36	17.03 ± 3.78	<0.0001
Palatal length (mm)		11.58 ± 2.64	11.53 ± 2.94	0.876
Canal diameter (mm)	Crestal	3.22 ± 1.05	3.17 ± 1.12	0.685
	Medial	2.26 ± 0.97	2.09 ± 0.93	0.139
	Apical	2.91 ± 1.40	2.91 ± 1.36	0.965
	Mean	2.79 ± 0.94	2.76 ± 1.01	0.769
Bone thickness anterior to the canal (mm)	Crestal	6.32 ± 1.13	4.43 ± 1.62	<0.0001
	Medial	7.22 ± 1.56	6.77 ± 1.62	0.012
	Apical	9.84 ± 2.58	9.08 ± 2.51	0.01
	Mean	7.80 ± 1.37	6.77 ± 1.50	<0.0001
Palatal bone thickness (mm)	Crestal	2.52 ± 0.85	2.11 ± 0.80	<0.0001
	Medial	5.37 ± 1.35	4.91 ± 1.40	0.003
	Apical	8.24 ± 2.16	7.11 ± 2.07	<0.0001
	Mean	5.38 ± 1.27	4.71 ± 1.25	<0.0001

$P < 0.05$ is statistically significant. Buccal Length: Bone length anterior to the canal.

Table 4. **Comparative statistical analysis of dentate and edentate female subjects**

		Dentate (n = 413) Mean ± SD	Edentate (n = 103) Mean ± SD	*P*
Age (mm)		40.14 ± 15.58	56.18 ± 13.02	<0.0001
Canal length (mm)		10.39 ± 2.47	9.62 ± 2.31	0.004
Buccal length (mm)		19.52 ± 3.18	15.72 ± 3.46	<0.0001
Palatal length (mm)		10.63 ± 2.79	10.25 ± 2.46	0.200
Canal diameter (mm)	Crestal	2.67 ± 0.89	2.88 ± 0.96	0.033
	Medial	1.95 ± 0.87	1.98 ± 0.83	0.748
	Apical	2.67 ± 1.40	2.54 ± 1.37	0.404
	Mean	2.43 ± 0.85	2.47 ± 0.85	0.689
Bone thickness anterior to the canal (mm)	Crestal	5.86 ± 1.28	3.76 ± 1.57	<0.0001
	Medial	6.40 ± 1.39	6.10 ± 1.80	0.113
	Apical	8.92 ± 2.40	8.43 ± 2.04	0.058
	Mean	7.06 ± 1.37	6.10 ± 1.40	<0.0001
Palatal bone thickness (mm)	Crestal	2.06 ± 0.81	1.80 ± 0.59	<0.0001
	Medial	4.47 ± 1.24	4.25 ± 1.25	0.110
	Apical	7.00 ± 2.02	6.53 ± 1.96	0.035
	Mean	4.52 ± 1.18	4.18 ± 1.16	0.009

$P < 0.05$ is statistically significant. Buccal Length: Bone length anterior to the canal.

Table 5. **The percentage of canal morphologies of IC in dentate and edentate subjects according to gender**

Canal morphologies		Women (%)	Men (%)
Cylindrical	Dentate	46.97	34.61
	Edentate	39.80	35.23
Banana-like	Dentate	11.38	10.47
	Edentate	11.65	16.02
Hourglass-like	Dentate	17.19	21.15
	Edentate	12.62	22.85
Funnel-like	Dentate	24.45	28.20
	Edentate	35.92	31.42

same results when gender was considered. This is the first study looked into these interactions with such a large study group (933 patients). Liang et al. (2009) examined only incisive canal length and diameter on 120 CT scans and found greater values in men in accordance with the present results. Bornstein et al. (2010) examined 44 men and 56 women. They measured canal length, canal width, and buccal bone width; and reported statistically higher buccal bone width and canal length values in men (Bornstein et al. 2010). However, conversely to the present study results, they could not detect canal diameter differences between men and women. They suggested that type of the canal had a significant effect on diameter of incisive foramen, but there was no data about classification of canal types according to gender.

In second part of our study, the effect of presence of teeth to the canal characteristics in men and women were examined. When teeth were not present in the anterior maxilla, both incisive canal length and buccal bone dimensions decreased; however, canal diameter did not change with dental status in both genders. Our study correlates well with Liang et al.'s (2009) study; they reported longer canals in dentate patients with no statistical difference noted for the canal diameter. Mardinger et al. (2008) examined canal dimensions on 207 CT scans and reported a decrease in canal length in edentulous patients. Our results are in agreement with their findings. Based upon these findings, Mardinger et al. (2008) suggested that canal diameter enlarged with tooth loss, like maxillary sinus. On the contrary, Liang et al. (2009) study (120 CT) and present study (933 CT) could not support this hypothesis. Hence, more studies in this area are needed.

In the present study, edentulous women and men had shorter incisive canals than dentate ones. In accordance, Song et al. (2009) examined canal length in 56 maxilla with micro CT and reported decreased canal length in edentulous group. Mardinger et al. (2008) detected similar results; buccal bone width and length decreased in edentulous patients. Moreover, Bornstein et al. (2010) evaluated the effect of dental status on buccal bone width and reported that the width of the buccal bone is the highest in cases when both centrals are present vs. one or two missing central incisors. Similar to these results, bone width anterior to the canal was also detected higher in dentate men and women in the current study.

Conclusions

Our study demonstrates that gender had a significant influence on anatomic features of anterior maxilla and maxillary incisive canal dimensions. Effect of dental status especially on buccal bone dimensions should not be ignored when performing surgery in the anterior maxilla. CT imaging is a valuable tool to determine anatomic structures before any surgeries in this area including implant surgery.

The authors declare that they have no conflicts of interest.

References

Artzi, Z., Nemcovsky, C.E., Bitlitum, I. & Segal, P. (2000) Displacement of the incisive foramen in conjunction with implant placement in the anterior maxilla without jeopardizing vitality of nasopalatine nerve and vessels: a novel surgical approach. *Clinical Oral Implants Research* **11**: 505–510.

Bornstein, M.M., Balsiger, R., Sendi, P. & Von Arx, T. (2010) Morphology of the nasopalatine canal and dental implant surgery: a radiographic analysis of 100 consecutive patients using limited cone-beam computed tomography. *Clinical Oral Implants Research* **22**: 295–301.

Faitaroni, L.A., Bueno, M.R., Carvalhosa, A.A., Mendonca, E.F. & Estrela, C. (2011) Differential diagnosis of apical periodontitis and nasopalatine duct cyst. *Journal of Endodontics* **37**: 403–410.

Guncu, G.N., Yildirim, Y.D., Wang, H.L. & Tozum, T.F. (2011) Location of posterior superior alveolar artery and evaluation of maxillary sinus anatomy with computerized tomography: a clinical study. *Clinical Oral Implants Research* **22**: 1164–1167.

Jacobs, R., Lambrichts, I., Liang, X., Martens, W., Mraiwa, N., Adriaensens, P. & Gelan, J. (2007) Neurovascularization of the anterior jaw bones revisited using high-resolution magnetic resonance imaging. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* **103**: 683–693.

Kovisto, T., Ahmad, M. & Bowles, W.R. (2011) Proximity of the mandibular canal to the tooth apex. *Journal of Endodontics* **37**: 311–315.

Liang, X., Jacobs, R., Martens, W., Hu, Y., Adriaensens, P., Quirynen, M. & Lambrichts, I. (2009) Macro- and micro-anatomical, histological and computed tomography scan characterization of the nasopalatine canal. *Journal of Clinical Periodontology* **36**: 598–603.

Mardinger, O., Namani-Sadan, N., Chaushu, G. & Schwartz-Arad, D. (2008) Morphologic changes of the nasopalatine canal related to dental implantation: a radiologic study in different degrees of absorbed maxillae. *Journal of Periodontology* **79**: 1659–1662.

Mraiwa, N., Jacobs, R., Van Cleynenbreugel, J., Sanderink, G., Schutyser, F., Suetens, P., van Steenberghe, D. & Quirynen, M. (2004) The nasopalatine canal revisited using 2D and 3D CT imaging. *Dento maxillo facial Radiology* **33**: 396–402.

Song, W.C., Jo, D.I., Lee, J.Y., Kim, J.N., Hur, M.S., Hu, K.S., Kim, H.J., Shin, C. & Koh, K.S. (2009) Microanatomy of the incisive canal using three-dimensional reconstruction of microCT images: an ex vivo study. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* **108**: 583–590.

Tozum, T.F., Guncu, G.N., Yildirim, Y.D., Yilmaz, H.G., Galindo-Moreno, P., Velasco-Torres, M., Al-Hezaimi, K., Al-Sadhan, R., Karabulut, E. & Wang, H.L. (2012) Evaluation of incisive canal characteristics related to dental implant treatment with computerized tomography: a clinical multicenter study. *Journal of Periodontology*, **83**: 337–343.