Location and size of mandibular canal and cortical bone width in the second molar region

Hidehito Ogawa, Yusuke Kawashima

Department of Radiology, Nihon University School of Dentistry at Matsudo

Running title Location and size of the MC and cortical bone thickness in the second molar region.

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Corresponding author

Yusuke Kawashima

Department of Radiology, Nihon University School of Dentistry at Matsudo

2-870-1 Sakaecho-Nishi Matsudo, Chiba Japan 271-8587

Telephone: +81-47-360-9530

Fax: +81-47-360-9418

Email: kawashima.yuusuke@nihon-u.ac.jp

Abstract

Purpose

The purpose of this study was to evaluate age related and gender related differences by using computed tomography images between the roots of the second molars mandibular cortex and the mandibular canal as well as cortical bone width and mandibular canal diameter in a Japanese population.

Methods

359 patients were subcategorized by gender and age (group < <31 years, group <, 31-49 years, group <, <50 years). The distance between the inner border of the cortical bone and the mandibular canal, the cortical bone width and the mandibular canal diameter were measured on cross sectional images.

Results

In male mandibular left, the mandibular second molar distal root apex to superior cortical bone of mandibular canal is shorter in group II than in group <. Both buccal and lingual cortex width in both sides of the mandible were shorter in younger males than in older males. In females, the mandibular second molar distal root apex to superior cortical bone of mandibular canal was shorter in group I than in group III in

both sides of the mandible. The buccal cortex width was shorter in older females than in younger females.

Conclusion

Our study showed that age, gender and region may have influence on the location and size of the mandibular canal as well as cortical bone width in the second molar region among a Japanese population.

Introduction

The mandibular canal (MC) is a single channel, enclosed by bony tissue, forming an upward concave curve (1). Its two ends are made up of two foramina: the mandibular foramen at the back and the mental foramen at the front (1). The MC encloses neurovascular bundles such as the inferior alveolar nerve (IAN), artery and vein which supply the mandibular molar teeth and adjacent structures such as the gingiva (1-3). The nutrient canals are derived from the incisive branch of the IAN to supply teeth and gingival tissue in the anterior region of the mandible (1-3). The IAN is the most commonly injured nerve during the dental procedures such as dental implant placement (4, 5) , mandibular third molar extraction (6, 7) and root canal treatment (5, 8). When these procedures performed incorrectly, it can lead to neurologic deficits such as pain, paresthesia, or anesthesia (4-11). Three mechanisms of IAN damage from dental implant placements and endodontic procedures have been identified: mechanical, chemical and thermal (12, 13). Mechanical trauma to the IAN may occur from an injection, drilling technique, implant placement on or near the nerve (12), over extension and over instrumentation, or an iatrogenic error such as severance of the nerve (12, 14, 15). An irrigation solution or an endodontic intracanal medicament or sealer can chemically damage, the IAN (12, 15). Thermal injuries to the

IAN include overheating the implant drill, extended ultrasonic use, or placing overheated gutta-purcha in an overprepared canal (16).

The root apices of the mandibular second molar are the closest to the MC compared with the premolar and the first molar (17, 18). Therefore, dental procedures involving mandibular second molar may have the highest risk to have IAN injury. The dental implant placement can cause lingual cortex perforation and laceration of the branch of the sublingual artery, and moreover hemorrhage from the floor of mouth. There were some cases in which airway obstruction had occurred without treating the hemorrhage (19-22). Before performing invasive dental procedures in mandibular second molar region, it is imperative to know the position and size of the MC and cortical bone thickness. We have previously reported age-related changes and gender related differences of the distance between MC to teeth and cortical bone in Boston University Henry M. Goldman School of Dental Medicine, Boston Massachusetts (23). The age-related changes and gender related differences of the distance between MC to teeth and cortical bone has not been revealed in a Japanese population. Moreover, the proximity of MC to teeth and cortical bone as well as cortical bone thickness and mandibular canal diameter is essential to prevent complications in the second molar region. These data can use making dental equipment such as the root canal reamer, the root canal file and the dental implant tailored for Japanese.

The purpose of this study was to evaluate age related changes and gender related differences by using computed tomography (CT) images between the roots of the second molars mandibular cortex and mandibular canal as well as cortical bone width and mandibular canal diameter in a Japanese population.

Materials and Methods

This study was approved by the Institutional Review Board of the Nihon University School of Dentistry at Matsudo (EC12-009), and all patients signed an informed consent agreement for the CT examination. We have read the Helsinki Declaration and have followed the guidelines in this investigation. Of the 3342 patients who underwent CT imaging for evaluation of maxilla, mandible, and maxillary sinus diseases as out patients in Department of Radiology in Nihon University Hospital at Matsudo (Chiba, Japan), between January 2016 and October 2016, mandibular CT images of 359 consecutive patients (133males, 226females; mean age 40.1years; age range, 17-85 years) were analyzed retrospectively. The patients were subcategorized by gender and age (table 1). Exclusion criteria were missing second molar, history of trauma, tumors cysts, and periapical lesions presenting in mandibular posterior region, patients undergoing orthodontic treatment and mandible unobservable on CT images. The CT examinations were performed with a multidetector row CT scanner (Aquilion 64; Toshiba medical, Tochigi, Japan). For evaluation of maxilla, mandible and maxillary sinus, all patients were examined cranio facial area using radiographic protocol for maxilla, mandible, and maxillary sinus examination at our hospital as follows: tube voltage, 120kV; tube current, 100mA; field of view, 18 mm×18mm; helical pitch 41; rotation time, 1.0second; mean effective dose mSv; mean CTDIvol value 37.3mGy; mean DLP value, 520.3mGycm using a contiguous high-resolution algorithm for osseous structures (window level 500, windows wide 2800). The protocol consisted of axial scanning (0.50 mm) with production of axial multiplanar reformation (3.00 mm). All measurement data were obtained using the Ziostation v1.1x measurement system (Qi Imaging, Tokyo, Japan).

All images were evaluated retrospectively by 2 oral and maxillofacial radiologists who have 6 years' experience. After interval of 2 weeks, the distances of 4 locations in 12 patients were reevaluated for intra-observer and inter-observer reliability.

Measurement

In addition to the proximity of MC to teeth and cortical bone, the distance between inner border of cortical bone and MC, the cortical bone width and mandibular canal diameter were measured on the cross sectional images contained with the distal root apex of the mandibular second molar. Following 9 measurement items were measured on the cross sectional images.

① The mandibular second molar distal root apex (A) to superior cortical bone of mandibular canal (MC): A-MC (Fig.1)

② The inferior cortical border of the mandible to the inferior cortex to the MC: I-MC (Fig.1)

③ The buccal cortical border of the mandible to the MC: B-MC (Fig.1)

④ The lingual cortical border of the mandible to the MC: L-MC (Fig.1)

⑤ Inferior cortex width (Fig.2)

⑥ Buccal cortex width (Fig.2)

⑦ Lingual cortex width (Fig.2)

⑧ Vertical canal diameter (Fig.3)

⑨ Horizontal canal diameter (Fig.3)

①, ②, ⑤ and ⑧ were measured vertical to the occlusal plane. ③, ④, ⑥, ⑦ and ⑨ were measured parallel to the occlusal plane.

Statistical analysis

The Mann-Whitney U test to compare the gender differences and Steel-Dwass test was used to compare inter-age group differences. *P* values less than .05 were considered statistically significant.

Results

Intra-observer and Inter-observer Reliability

Intra- and inter-observer reliability was assessed to determine the validity of measurements taken in this study. By using kappa statistics, the correlation coefficient ranged from 80% to 100%. Therefore, the influence of the measurement errors on the statistical procedure of the results seemed to be extremely small.

Age related changes

In left side of the male mandible (table 2), the mandibular second molar distal root apex to superior cortical bone of mandibular canal distance was significantly shorter in group < than in group < ($P<.05$). The buccal cortical border of the mandible to the mandibular canal distance was significantly longer in group < than in group < ($P<.05$). The buccal cortex width was significantly longer in group < than in group < ($P<.01$), significantly longer in group < than in group < ($P<.01$). The lingual cortex width was significantly longer in group < than in group < ($P<.01$), significantly longer in group < than in group < ($P<.01$).

In left side of the female mandible (table 3), the mandibular second molar distal root apex to superior cortical bone of mandibular canal distance was significantly shorter in group < than in group < ($P<.01$). The inferior cortex width was significantly longer in group < than in group < ($P<.05$), significantly longer in group < than in group < ($P<.01$). The buccal cortex width was significantly longer in group < than in group < ($P<.01$), significantly longer in group < than in group < ($P<.01$). The horizontal canal diameter was significantly shorter in group < than in group < ($P<.01$), significantly shorter in group < than in group < ($P<.01$).

In right side of the female mandible (table 3), the mandibular second molar distal root apex to superior cortical bone of mandibular canal distance was significantly shorter in group < than in group < ($P<.01$). The buccal cortical border of the mandible to the mandibular canal distance was significantly longer in group < than in group < ($P<.05$). The inferior cortex width was significantly longer in group < than group < ($P<.01$), significantly longer in group < than in group < ($P<.01$). The buccal cortex width was significantly longer in group < than in group < ($P<.01$), significantly longer in group < than in group < ($P<.01$). The horizontal canal diameter was significantly shorter in group < than in group < ($P<.05$).

Gender differences

When comparing left side of the mandible between males and females in group < (table 3), the buccal cortical border of the mandible to the mandibular canal distance was significantly longer in males than in females ($P<.05$). The lingual cortical border of the mandible to the mandibular canal distance was significantly shorter in males than in females (*P*<.01). The buccal cortex width was significantly shorter in males than in females (*P*<.01). The vertical canal diameter was significantly longer in males than in females (*P*<.05). The horizontal canal diameter was significantly longer in males than in females (*P*<.01).

Comparing right side of the mandible between males and females in group < I (table 4), the buccal cortical width was significantly shorter in males than in females (*P*<.01). The horizontal canal diameter was significantly longer in males than in females (*P*<.01).

Comparing left side of the mandible between males and females in group < I (table 5), the buccal cortical border of the mandible to the mandibular canal distance was significantly longer in males than in females (*P*<.01). The buccal cortical width was significantly shorter in males than in females (*P*<.01). The vertical canal diameter was significantly longer in males than in females (*P*<.01).

Comparing right side of the mandible between males and females in group < I (table 5), the buccal cortical border of the mandible to the mandibular canal distance was significantly longer in males than in females (*P*<.01). The buccal cortical width was significantly shorter in males than in females (*P*<.01).

Comparing left side of the mandible between males and females in group < II (table 6), the inferior cortical border of the mandible to the inferior cortex to the mandibular distance was significantly longer in males than in females ($P<.05$). The lingual cortical width was significantly shorter in males than in females ($P<.05$). The vertical canal diameter was significantly longer in males than in females ($P<.05$).

Comparing right side of the mandible between males and females in group < I (table 6) the inferior cortical border of the mandible to the inferior cortex to the mandibular distance was significantly longer in males than in females ($P<.01$).

Discussion

Our study showed that the location and size of mandibular canal as well as the thickness of the cortical bone in the second molar region are different between males and females. The location of mandibular canal and the thickness of the cortical bone in the second molar region change with age in both males and females. The measurement data which the mean was almost equal or smaller than the standard deviation may be the part that have greater individual differences.

Age related changes

Our results revealed that left mandibular canal runs closer to the mandibular second distal root in male group < than in male group < and male group <. This trend was similar to prior study (18, 23). Kovisto et al. (18) reported the root apices in younger patients (<18years) were closer to the mandibular canal than in older patients (18years≧). The mandibular canal runs closer to the buccal cortical border of the mandible in male group < than in male group < and male group <. To our knowledge, age-related changes of the buccal cortical border of the left mandible distance has not been reported. Our results indicate that the left mandibular canal in males move downward (18) and move buccal with age. The reason that the mandibular canal moves downward may be affected by the occlusion or age related changes of the trabecular bone. The Both the buccal cortex width and the lingual cortex width were shorter in male group < than in male group < and male group < . Boskey et al. (25) reported the cortical bones thinning occur in human with age. There are few reports which have evaluated the age-related changes of the mandibular cortex width in males. Our results indicate the buccal cortex and the lingual cortex width decrease with age in males.

Our results revealed that significant changes were not found in male mandibular right. This suggests the location and size of the right mandibular canal does not change with age in males.

Our results suggests that these changes may reflect age related changes as well as the generation differences.

Gender related differences

In females, the mandibular canal is closer to the second molar root apices in group < than in group < in both sides of the mandible. This trend was similar to prior study (18, 23). Our results suggest the mandibular canal runs closer to the mandibular second molar root apices in younger patients than older patients in both sides of the female mandible. In female mandibular right, the mandibular canal takes more buccal in group < than group < . Our results indicate that the mandibular canal moves to buccal side border of the mandible with age in female mandibular left. Our results revealed that both the inferior cortex width and the lingual cortex width decrease with age in both sides of the female mandible. Riggs et al. (26) reported that after the menopause, the general skeletal bone mass decreases due to estrogen deficiency leads to osteoporosis. Klemetti et al. (27) reported the mandibular bone mass and cortical thickness were related to osteoporosis. Taguchi et al. (28) reported the mandibular inferior cortical width and 3rd lumber bone mineral density showed linear negative relation. Our results indicate the inferior cortex width and in both sides of the female mandible may be affected by skeletal bone mass decrease. Our results indicate the lingual cortex width may be correlated with bone remodeling. The horizontal canal diameter was shorter in younger patients in female mandibular right. There are few reports evaluated age-related changes of the horizontal canal diameter in female mandibular right. Our results indicate the inferior alveolar nerve extent to horizontally with age in female mandibular right.

When comparing male with female in same side of the mandible, the left mandibular canal takes closer to lingual border of the mandible in male group < than in female <, same trend was seen in male group < than in female group <. The right mandibular canal more buccal course in female group < than in male group <. Our results were different from the Oliveira et al. (29) study that the mandibular canal runs lingual course in both sides of the mandible. This may be result of difference of ethnic group. Our results revealed both sides of the mandibular canal run closer to the inferior cortical border of the mandible in female group < than in male group < . This may be the fact that men has larger body size than women (23) and show differences between the inferior cortical border of the mandible to the inferior cortex to the mandibular canal. The buccal cortex width was shorter in both sides of the mandible in male in female in group < and < . Same trend was seen in the left lingual cortex width that male is shorter than female. To our knowledge, there are few reports which have showed the difference of the cortical bone width between males and females. Our results indicate the buccal and the lingual cortex width may be affected by the gender differences. The canal diameter was longer in males than in females in both sides of the mandible in group < , the left mandibular in group < and group < . This may be fact of the gender difference (23).

Our study showed that age and gender may effect on the location and size of the mandibular canal as well as cortical bone width in the second molar region among Japanese. These findings may useful to prevent complications of surgery in the mandibular second molar region.

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Table 1 number of the patients in group I, II and III

	group I	group II	group III
age	<31 years	31-49 years	50-85 years
total number of patients	119	151	89
number of males	42	61	30
number of females	77	90	59

Table 2 Age related changes of the both sides of the mandible in males. The data in the table shows mean±SD(median).

	left			right		
	group I	group II	group III	group I	group II	group III
A- MC (mm)	3.11 ± 2.62 (3.01)	3.22 ± 2.36 (2.60)	5.59 ± 5.76 (4.50) *	3.22 ± 2.8 (2.55)	3.64 ± 2.62 (3.4)	4.37 ± 2.94 (3.66)
I-MC (mm)	8.45 ± 1.85 (8.55)	8.41 ± 2.03 (8.2)	9.07 ± 1.88 (9.1)	8.47 ± 1.82 (8.6)	8.52 ± 2.14 (8.31)	9.28 ± 2.04 (9.4)
B-MC (mm)	8.21 ± 1.29 (8.3)	8.07 ± 1.53 (8.1)	7.48 ± 1.20 (7.6) *	7.87 ± 1.61 (7.75)	8.07 ± 1.63 (8.1)	7.64 ± 1.14 (7.66)
L-MC (mm)	2.31 ± 1.03 (2.1)	2.50 ± 0.94 (2.6)	2.82 ± 1.37 (2.6)	2.44 ± 1.14 (2.1)	2.38 ± 0.95 (2.4)	2.82 ± 1.46 (2.7)
inferior cortex width (mm)	3.22 ± 0.48 (3.2)	3.32 ± 0.53 (3.3)	3.12 ± 0.59 (3.1)	3.30 ± 0.51 (3.3)	3.34 ± 0.55 (3.3)	3.07 ± 0.74 (3)
buccal cortex width (mm)	** 2.04 ± 0.46 (2.1)	2.09 ± 0.57 (1.9)	** 1.64 ± 0.55 (1.7)	2.00 ± 0.50 (1.9)	2.08 ± 0.56 (2)	1.80 ± 0.51 (1.8)
lingual bone width (mm)	** 1.60 ± 0.43 (1.5)	1.64 ± 0.47 (1.6)	** 1.38 ± 0.49 (1.3)	1.62 ± 0.49 (1.5)	1.52 ± 0.53 (1.5)	1.42 ± 0.37 (1.4)
vertical canal diameter (mm)	3.09 ± 0.62 (3)	3.31 ± 0.61 (3.2)	3.30 ± 0.55 (3.2)	3.01 ± 0.61 (2.9)	3.10 ± 0.64 (3)	3.32 ± 0.77 (3.11)
horizontal canal diameter (mm)	2.48 ± 0.41 (2.5)	2.63 ± 0.46 (2.6)	2.58 ± 0.65 (2.7)	2.54 ± 0.34 (2.6)	2.62 ± 0.54 (2.5)	2.70 ± 0.72 (2.7)

*; P<.05

**; P<.01

Table 3 Age related changes of the both sides of the mandible in females. The data in the table shows mean±SD(median).

	left			right		
	group I	group II	group III	group I	group II	group III
			**			**
A- MC (mm)	3.22±2.8 (2.55)	3.64±2.62 (3.4)	4.37±2.94 (3.66)	2.16±2.29 (2.2)	3.25±3.55 (2.9)	4.16±2.94 (3.9)
I-MC (mm)	8.47±1.82 (8.6)	8.52±2.14 (8.31)	9.28±2.04 (9.4)	8.31±1.90 (8.2)	7.84±1.94 (8.2)	8.12±1.77 (7.9)
						**
B-MC (mm)	7.87±1.61 (7.75)	8.07±1.63 (8.1)	7.64±1.14 (7.66)	7.74±1.53 (7.7)	7.36±1.38 (7.4)	7.12±1.35 (7.3)
L-MC (mm)	2.44±1.14 (2.1)	2.38±0.95 (2.4)	2.82±1.46 (2.7)	2.73±1.10 (2.7)	2.95±3.25 (2.8)	2.89±1.15 (2.9)
inferior cortex width (mm)	3.30±0.51 (3.3)	3.34±0.55 (3.3)	3.07±0.74 (3)	3.47±0.56 (3.5)	3.54±0.92 (3.5)	3.01±0.84 (3.1)
	*		**	**		**
buccal cortex width (mm)	2.00±0.50 (1.9)	2.08±0.56 (2)	1.80±0.51 (1.8)	2.43±0.65 (2.3)	2.39±0.50 (2.4)	1.96±0.86 (2)
	**		**	**		**
lingual bone width (mm)	1.62±0.49 (1.5)	1.52±0.53 (1.5)	1.42±0.37 (1.4)	2.73±1.10 (1.6)	1.52±0.41 (1.5)	1.44±0.48 (1.3)
vertical canal diameter (mm)	3.01±0.61 (2.9)	3.10±0.64 (3)	3.32±0.77 (3.11)	3.18±3.44 (2.8)	2.92±0.69 (2.9)	2.87±0.51 (2.8)
	**		**		*	
horizontal canal diameter (mm)	2.54±0.34 (2.6)	2.62±0.54 (2.5)	2.70±0.72 (2.7)	2.36±0.55 (2.3)	2.54±0.54 (2.5)	2.52±0.44 (2.4)

* ; *P*<.05
** ; *P*<.01

Table 4 Gender related changes of the both sides of the mandible in group < . The data in the table shows mean±SD(median).

	left		right	
	male	female	male	female
A- MC (mm)	3.11±2.62 (3.01)	2.27±2.04 (2)	3.22±2.8 (2.55)	2.16±2.29 (2.2)
I-MC (mm)	8.45±1.85 (8.55)	8.31±2.00 (8.4)	8.47±1.82 (8.6)	8.31±1.90 (8.2)
	└── * ──┘			
B-MC (mm)	8.21±1.29 (8.3)	7.61±1.53 (7.6)	7.87±1.61 (7.75)	7.74±1.53 (7.7)
	└── ** ──┘			
L-MC (mm)	2.31±1.03 (2.1)	2.94±1.16 (2.9)	2.44±1.14 (2.1)	2.73±1.10 (2.7)
inferior cortex width (mm)	3.22±0.48 (3.2)	3.40±0.51 (3.3)	3.30±0.51 (3.3)	3.47±0.56 (3.5)
	└── ** ──┘		└── ** ──┘	
buccal cortex width (mm)	2.04±0.46 (2.1)	2.34±0.46 (2.3)	2.00±0.50 (1.9)	2.43±0.65 (2.3)
lingual bone width (mm)	1.60±0.43 (1.5)	2.94±1.16 (1.7)	1.62±0.49 (1.5)	2.73±1.10 (1.6)
	└── * ──┘			
vertical canal diameter (mm)	3.09±0.62 (3)	2.79±0.48 (2.8)	3.01±0.61 (2.9)	3.18±3.44 (2.8)
	└── ** ──┘		└── ** ──┘	
horizontal canal diameter (mm)	2.48±0.41 (2.5)	2.30±0.44 (2.3)	2.54±0.34 (2.6)	2.36±0.55 (2.3)

* ; *P*<.05

** ; *P*<.01

Table 5 Gender related changes of the both sides of the mandible in group < . The data in the table shows mean±SD(median).

	left		right	
	male	female	male	female
A- MC (mm)	3.22±2.36 (2.60)	2.85±2.33 (2.8)	3.64±2.62 (3.4)	3.25±3.55 (2.9)
I-MC (mm)	8.41±2.03 (8.2)	7.94±1.78 (7.8)	8.52±2.14 (8.31)	7.84±1.94 (8.2)
B-MC (mm)	8.07±1.53 (8.1)	7.13±1.37 (7.2) **	8.07±1.63 (8.1)	7.36±1.38 (7.4) **
L-MC (mm)	2.50±0.94 (2.6)	2.92±1.01 (3) *	2.38±0.95 (2.4)	2.95±3.25 (2.8)
inferior cortex width (mm)	3.32±0.53 (3.3)	3.56±1.00 (3.4)	3.34±0.55 (3.3)	3.54±0.92 (3.5)
buccal cortex width (mm)	2.09±0.57 (1.9)	2.29±0.45 (2.3) **	2.08±0.56 (2)	2.39±0.50 (2.4) **
lingual bone width (mm)	1.64±0.47 (1.6)	1.65±0.54 (1.7)	1.52±0.53 (1.5)	1.52±0.41 (1.5)
vertical canal diameter (mm)	3.31±0.61 (3.2)	2.86±0.67 (2.7) **	3.10±0.64 (3)	2.92±0.69 (2.9)
horizontal canal diameter (mm)	2.63±0.46 (2.6)	2.51±0.44 (2.4)	2.62±0.54 (2.5)	2.54±0.54 (2.5)

* ; $P<.05$

** ; $P<.01$

Table 6 Gender related changes of the both sides of the mandible in group < . The data in the table shows mean±SD(median).

	left		rigth	
	male	female	male	female
A- MC (mm)	5.59±5.76 (4.50)	3.98±2.91 (3.5)	4.37±2.94 (3.66)	4.16±2.94 (3.9)
		*		**
I-MC (mm)	9.07±1.88 (9.1)	8.18±2.06 (8.2)	9.28±2.04 (9.4)	8.12±1.77 (7.9)
B-MC (mm)	7.48±1.20 (7.6)	7.07±1.41 (7.1)	7.64±1.14 (7.66)	7.12±1.35 (7.3)
L-MC (mm)	2.82±1.37 (2.6)	3.02±0.96 (3.1)	2.82±1.46 (2.7)	2.89±1.15 (2.9)
inferior cortex width (mm)	3.12±0.59 (3.1)	3.05±1.05 (3.1)	3.07±0.74 (3)	3.01±0.84 (3.1)
buccal cortex width (mm)	1.64±0.55 (1.7)	1.84±0.76 (1.8)	1.80±0.51 (1.8)	1.96±0.86 (2)
		*		
lingual bone width (mm)	1.38±0.49 (1.3)	1.59±0.57 (1.5)	1.42±0.37 (1.4)	1.44±0.48 (1.3)
		*		
vertical canal diameter (mm)	3.30±0.55 (3.2)	2.99±0.62 (3)	3.32±0.77 (3.11)	2.87±0.51 (2.8)
horizontal canal diameter (mm)	2.58±0.65 (2.7)	2.64±0.51 (2.5)	2.70±0.72 (2.7)	2.52±0.44 (2.4)

*; *P*<.05

##; *P*<.01

Fig. 1 The measeurement between the distal root apex of the second molar to the mandibular canal (MC), inferior corex, buccal cortex and lingual coretex. ① The mandibular second molar distal root apex to superior cortical bone of mandibular canal (A-MC), ② The inferior cortical border of the mandible to the inferior cortex to the mandibular canal (I-MC), ③ The buccal cortical border of the mandible to the mandibular canal (B-MC), and ④ The lingual cortical border of the mandible to the mandibular canal (L-MC).

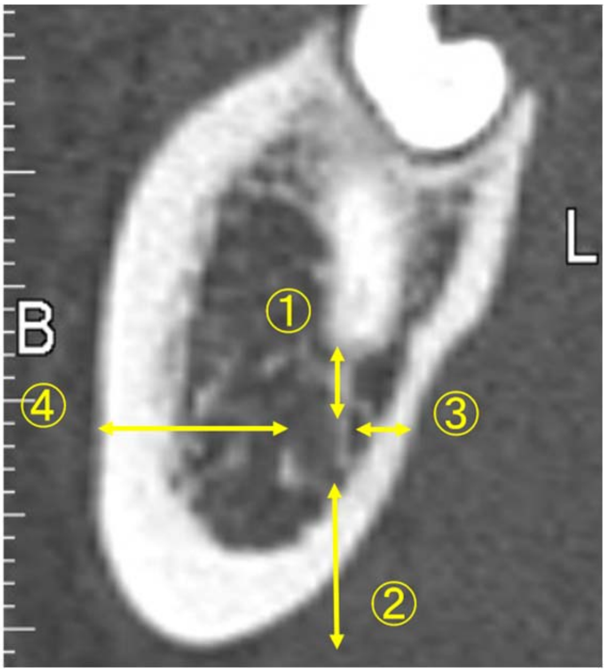

Fig. 2 The measeurementof the inferior cortex, the buccal and the lingual cortex. ⑤ Inferior cortex width, ⑥ Buccal cortex width, and ⑦ Lingual cortex width.

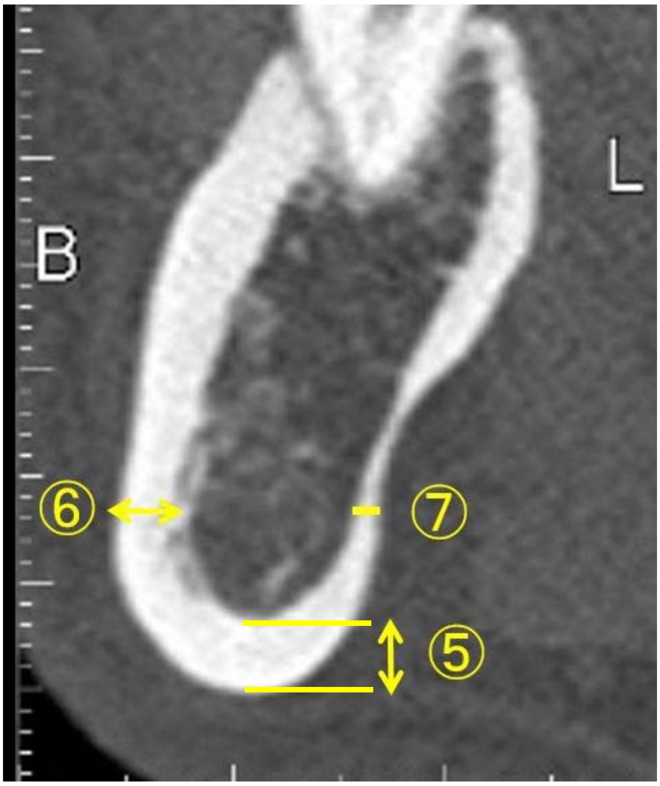

Fig. 3 The measeurementof the vertical and the horizontal canal diameter of MC. ⑧ Vertical canal diameter, and ⑨ Horizontal canal diameter.