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Anatomic measurement of the depth and location of the sublingual fossa

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Abstract. The purpose of this study was to measure the depth and location of the sublingual fossa, a potential site of sublingual bleeding/lingual cortical perforation during endosseous implant placement in the mandibular interforaminal region (MIR), to clarify anatomical variation. Using the mandibles of 37 Japanese cadavers, the lingual depth (LD) between the lingual surface and the line perpendicular to the inferior margin of the mandible (IMM), as well as the vertical distance (VD) between the lingual surface and the IMM or the mental foramen (MF) level, were measured at defined points and lines within the MIR. The definite sublingual fossa (SF) was identified by the LD ($\geq$1.0 mm) and the VD, and the depth and location of the SF were determined. The depth ranged between 1.0 mm and 5.8 mm, and the vertical location ranged between 9.2 mm and 15.7 mm from the IMM and between 2.2 mm and 6.1 mm from the MF level. These results revealed certain tendencies in the depth and location of the SF but the variation was substantial. The SF should be identified in each case as accurately as possible by CT before implant placement in the MIR to minimize the risk of the potential complications.

Keywords: anatomic measurement; sublingual fossa; perforation; bleeding..

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In 1981, Adell et al.[1] reported a procedure for installing endosseous implants (hereafter, implants) in the mandibular interforaminal region (MIR) for edentulous patients. The procedure avoided the mandibular canal during implant placement and was considered to incur relatively few complications. Some life-threatening cases complicated by haemorrhage have been reported during or following the procedure.[2–16] These complications are likely to occur because drilling or implant placement perforates the lingual cortical bone and damages the submental artery (a branch of the facial artery) or the sublingual artery (a branch of the lingual artery) coursing by the lingual cortical bone.[2,17–20] Factors that might be linked to the complications include: size, shape, and length of the implant[21]; direction of placement[21]; possible bone pathology[22]; surgical skill of the operator[21]; preoperative assessment including imaging[21]; systemic factors including medical history[23]; and anatomical variation of the site.[21] Regarding the anatomical variation of the site, Krenkel and Holzner,[2] Mordenfeld et al.[7] and Hofschneider et al.[18] have emphasized the importance of obtaining morphologic information on the sublingual fossa in the MIR. No studies have described the anatomic variation of the sublingual fossa.

The authors attempted to measure the depth and location of the sublingual fossa anatomically in the MIR to investigate the variation, to provide basic morphologic data that may assist virtual measurement by computed tomography (CT).

Materials and methods

37 Japanese cadavers (36 right and 35 left hemi-mandibles; total 71) used in the Department of Anatomy of Saga Medical

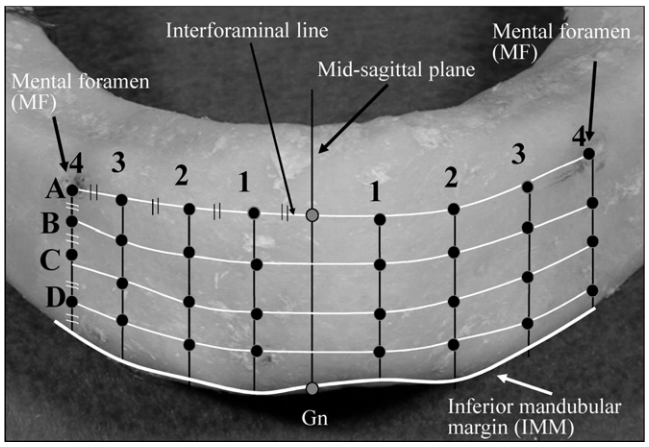

Fig. 1. Grid pattern defined on the interforaminal labial surface of the mandible.

School were examined under the approval of the Ethics Committee at Saga Medical School. All the cadavers had been stored in 10% neutral formalin solution. Three hemi-mandibles damaged during the gross anatomy course at Saga Medical School were excluded from the study.

22 male (43 hemi-mandibles) and 15 female (28 hemi-mandibles) cadavers were used; the age at the time of death was 45–96 years (mean 74.7 years). The specimens were divided into two age groups for statistical analysis: 45–75 years (19 cadavers; 37 hemi-mandibles); and 76–96 years (18 cadavers; 34 hemi-mandibles). The 71 hemi-mandibles were divided into two groups according to dental status: a dentate group with at least 1 tooth (36 hemi-mandibles); and an edentulous group with no teeth (35 hemi-mandibles).

The mandible was detached from the cadaver and completely exposed. The mandible sample was placed on a flat experimental table and the inferior margin of the mandible (IMM) was defined as the reference plane (Fig. 1).[24–26] A line (interforaminal line) drawn between the right and left mental foramen (MF) parallel to the IMM was defined on the labial surface of the mandible (Fig. 1).[24–26] A mid-sagittal plane was defined by connecting the central point of the interforaminal line, the tip of the mental spine, and the centre of the IMM (gnathion; Gn) (Fig. 1).[24–26] The interforaminal line on the mandibular labial surface was divided into left and right parts from the mid-sagittal plane, each of which was then divided into four equivalent lines (Fig. 1). The vertical lines between the interforaminal line and the IMM on the mandibular labial surface were divided into four equivalent lengths to create a grid-like pattern on the MIR. The vertical lines were designated 1–4 mesially for both sides, and the horizontal lines were designated A–D from the alveolar crest. The intersections (32 points) of the vertical and horizontal lines on the labial cortical surface were defined (Fig. 1).

The points on the lingual cortical surface corresponding to those on the labial cortical surface were defined using callipers (Code-Nr.209-602; Mitutoyo Corporation, Kanagawa, Japan) with a parallel indicator (Fig. 2a) as follows: the mandibular bone was placed labiolingually between the callipers and the position was adjusted so that the parallel indicator was parallel with the IMM; with one jaw of the callipers placed at an intersection of the vertical and horizontal lines on the labial cortical surface, the point at which the other jaw was placed was defined as the corresponding point of the lingual cortical surface (Fig. 2b); and similar to the labial cortical surface, the vertical (1–4) and horizontal lines (A–D) were defined on the basis of the points defined on the lingual cortical surface (Fig. 3).

The measurements were obtained from the left and right hemi-mandibles. The lines perpendicular to the IMM from the reference points (A1, A2, A3, and A4 (MF level)) were defined, and the lingual depths (LDs) from these lines to the 12 intersection points of the vertical and horizontal lines on the lingual cortical surface (points on the B–D levels) were measured (Fig. 4). The vertical distances (VDs) from the IMM to the horizontal lines (A–D levels) and from horizontal line A (MF level) to horizontal lines B–D were measured (Fig. 5).

A depth gauge (Kohler, Neuhausen, Germany) and callipers (N10S; Mitutoyo Corporation) were used for all measurements. All the measurements were performed by one expert. The measurements for a site were repeated three times, and the average was obtained.

The presence of the sublingual fossa was grossly observed, and the point with the largest LD in the defined 12 points nearest to the sublingual fossa was identified. When the nearest and deepest point in a sample had an LD $\geq$ 1.0 mm, the point was regarded as the definite sublingual fossa (SF) as shown in Fig. 6. The depth of the SF was determined as the LD of the deepest point, and the location was determined from the VD between the IMM and the SF and the VD between the MF level and the SF for each sample. The location of the tooth corresponding to the SF was

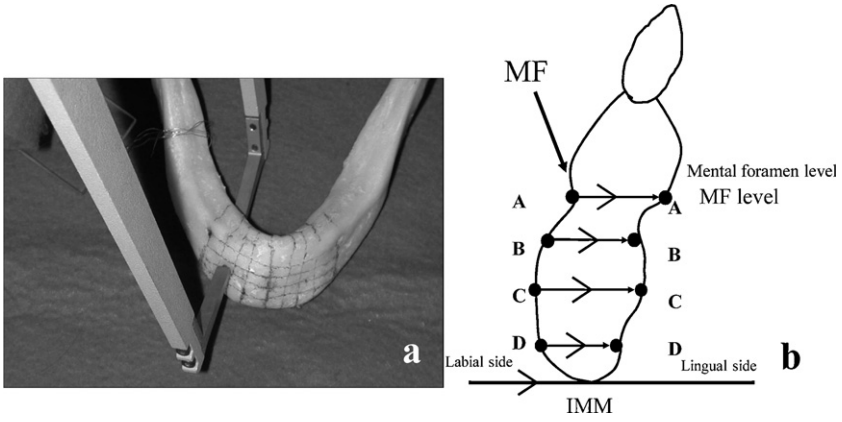

Fig. 2. Definition of the points on the lingual side using the callipers with parallel indicator (a) and sagittal cross section near the mental foramen (MF) of the mandible (b). (a) The mandibular bone was placed labiolingually between the callipers on the flat table, and the position was adjusted so that the parallel indicator was parallel with the inferior margin of the mandible (IMM). (b) With one jaw of the callipers placed at a defined point on the labial cortical surface, the point at which the other jaw was placed in parallel was defined as the corresponding point of the lingual cortical surface.

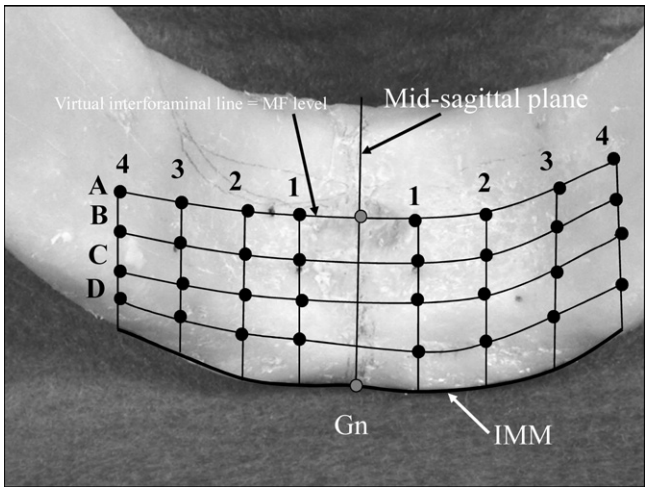

Fig. 3. Grid pattern defined on the mandibular lingual surface. The horizontal line A represents the virtual interforaminal line corresponding to the MF level.

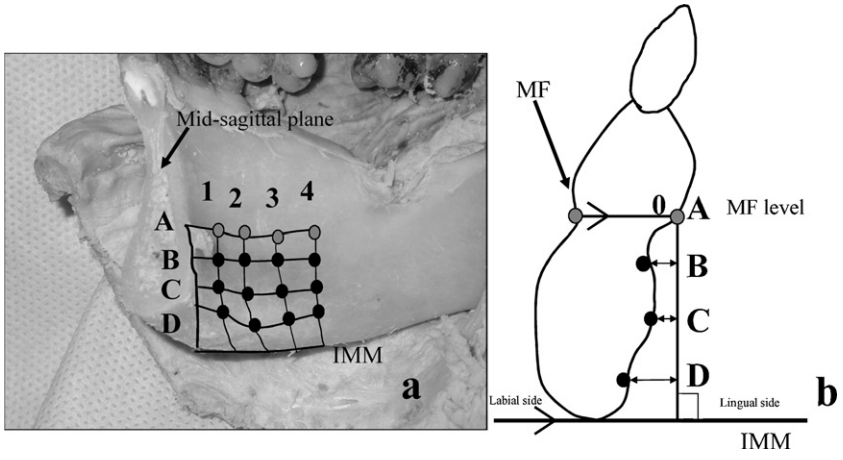

Fig. 4. The mandibular lingual surface (a) and the sagittal cross section near the mental foramen (b). (a) 12 points (black circles) are defined on the mandibular lingual surface to measure the lingual depth. (b) The lines perpendicular to the IMM from the reference points (A1, A2, A3, and A4) were defined, and the lingual depths (LDs) from these lines to the 12 intersection points were measured as indicated by the double-headed arrows.

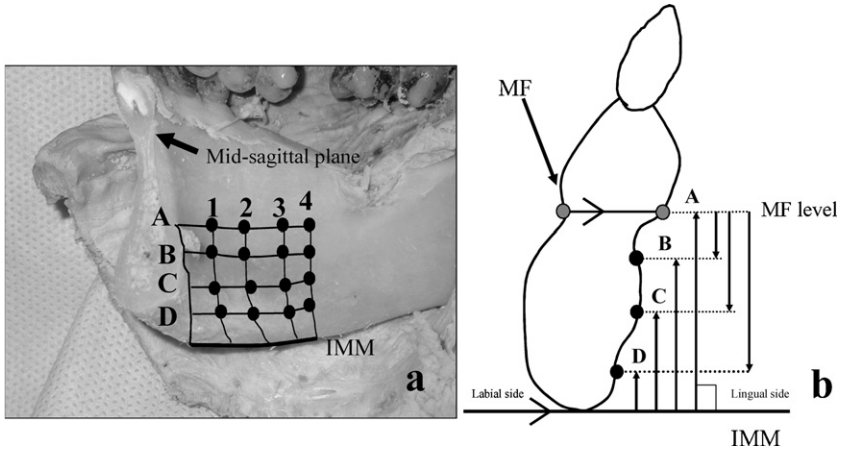

Fig. 5. The mandibular lingual surface (a) and the sagittal cross section near the mental foramen (b). (a) The horizontal lines of A–D are defined on the basis of 16 points on the lingual cortical surface. (b) The vertical distances (VDs) from the IMM to the horizontal lines (arrows pointing up) (A–D levels) and those from horizontal line A (MF level) to horizontal lines B–D (arrows pointing down) were measured.

also confirmed. In the edentulous group, the location was determined on the basis of the average mesiodistal diameter of the permanent teeth from the mid-sagittal plane in Japanese adults.[27] The frequency of the presence of SF was calculated as a total of all samples, as well as by gender, age, and dental status.

All statistical analyses were processed using SPSS statistical software (version 11.0J, SPSS, Tokyo, Japan). For comparison of the frequency of the presence of SF by gender, age, and dental status, a χ^2 test was used.

A comparison between the dentate and edentulous groups in the specimens with the SF was performed using an unpaired Student's t test. P values < 0.05 were considered statistically significant.

Results

SFs were present in 45% of all samples (32/71 hemi-mandibles), 58% of male samples (25/43 hemi-mandibles), 25% of female samples (7/28 hemi-mandibles) (Table 1), 49% of 45–75 year old samples (18/37 hemi-mandibles), 41% of 76–96 year old samples (14/34 hemi-mandibles) (Table 2), 58% of dentate samples (21/36 hemi-mandibles), and 31% of edentulous samples (11/35 hemi-mandibles) (Table 3). The frequency of the presence of SF was statistically significantly higher in the male and/or

Table 1. Number of hemi-mandible samples with and without the definite sublingual fossa (SF) by gender.

	With SF	Without SF	Total
Male	25	18	43
Female	7	21	28
Total	32	39	71

$P = .006 < .05$.

Table 2. Number of hemi-mandible samples with and without the definite sublingual fossa (SF) by age.

	With SF	Without SF	Total
45–75 yr	18	19	37
76–96 yr	14	20	34
Total	32	39	71

$P = .53 > .05$.

Table 3. Number of hemi-mandible samples with and without the definite sublingual fossa (SF) by dental status.

	With SF	Without SF	Total
Dentate	21	15	36
Edentulous	11	24	35
Total	32	39	71

$P = .02 < .05$.

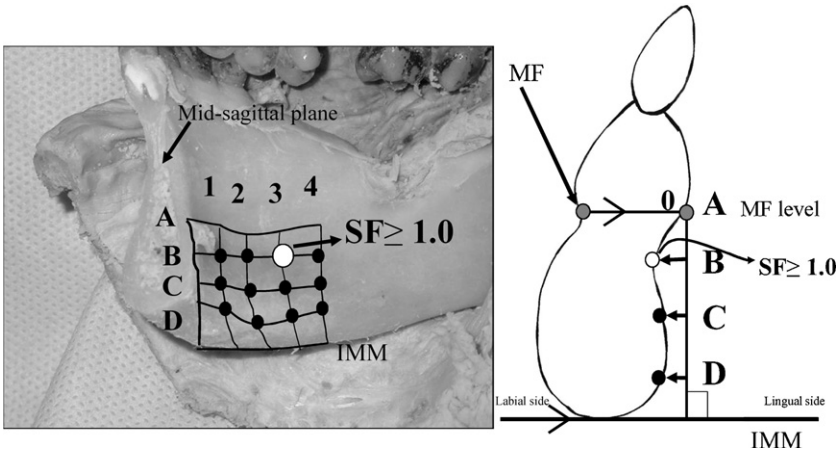

Fig. 6. Of the 12 defined points, the nearest and deepest point that had an LD ≥ 1.0 mm was regarded as the SF.

Table 4. Range and mean ± SD of lingual depth (LD) and vertical distances (VD) in all samples with the SF. Unit: mm, $n = 32$.

Measurement	Range	Mean ± SD
LD of SF	1.0–5.8	1.7 ± 1.0
VD from IMM to SF	9.2–15.7	12.5 ± 1.9
VD from MF level to SF	2.2–6.1	4.1 ± 0.9

dentate samples than in the female and/or edentate samples ($P = 0.006 < 0.05$ and $P = 0.02 < 0.05$, respectively) (Tables 1 and 3), whereas the difference was not statistically significant between the 45–75 and the 76–96 year old groups ($P = 0.53 > 0.05$) (Table 2).

The ranges and mean ± standard deviation (SD) of the LD of the SF, the VD from the IMM to the SF, and the VD from the MF level to the SF in all samples with the SF are shown in Table 4. The SF of all 32 hemi-mandibles with SF was vertically located on the B level above the mylohyoid line (Fig. 4b). The horizontal location of the SF corresponded to B2, B3, or B4 in all of the 32 hemi-mandibles (Fig. 4a). The SF was located in the canine or premolar region in all of the samples.

The ranges and mean ± SD of the LD of the SF, the VD from the IMM to the SF, and the VD from the MF level to the SF in the dentate and edentulous groups are shown in Table 5. In the statistical comparison between the two groups, both the LD of the SF and the VD from the IMM to the SF were significantly larger in the dentate group than in the edentulous group ($P < 0.05$). No statistically significant difference was found in the VD from the MF level to the SF between the groups.

The LD in the sample with the deepest SF was 5.8 mm, which was at B3 in the first premolar region, and the VDs from the IMM to the SF and from the MF level to the SF were 14.5 mm and 5.3 mm, respectively (Fig. 7).

Discussion

The frequency of the presence of SF showed a statistically significant difference according to gender and dental status in this study. The male and dentate groups showed significantly higher values than the female and edentulous groups ($P < 0.05$). The dentate group also showed statistically significantly higher values than the edentulous group in the LD of the SF. The number of cases in which the lingual cortical bone was perforated, the vessels were damaged, and serious haemorrhage was observed in the floor of the mouth during implant placement in the MIR has been reported to be 6 in males, 10 in females, 9 in the edentulous group and 7 in the dentate group (Table 6).[2–16] The records show that critical haemorrhage is likely to occur more frequently in females and/or the

Table 5. Range and mean ± SD of lingual depth (LD) and vertical distances (VD) for the SF in the dentate group and the edentulous group. Unit: mm.

Unit: mm

Measurement	Dentate Group n=21		Edentulous Group n=11	
	Range	Mean ± SD	Range	Mean ± SD
			*	
LD of SF	1.0 - 5.8	1.9± 1.0	1.0 - 2.5	1.4± 0.5
VD from IMM to SF	10.5 - 15.7	13.0± 1.6	9.2 - 15.0	11.5± 2.0
			*	
VD from MF level to SF	3.2 - 6.1	4.3± 0.9	2.2 - 4.7	3.7± 0.9

*p<.05

$P < .05$.

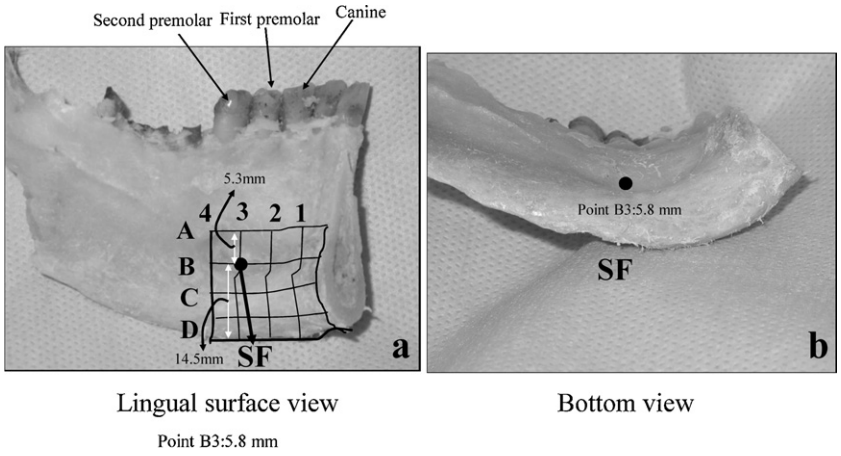

Fig. 7. Sample with the deepest SF. (a) Lingual surface view of the mandible. The SF is at B3 in the first premolar region, the LD was 5.8 mm and the VDs from the IMM to the SF and from the MF level to the SF were 14.5 mm and 5.3 mm, respectively. (b) Bottom view of the mandible. The SF is observed at B3 in the first premolar region.

edentulous than in males and/or the dentate. The reason for the high frequency of serious bleeding on the floor of the mouth reported in female and edentate patients may be related to the slender mandible bone in females[28] and bone resorption following tooth loss in the edentulous[29] rather than the presence of SF. The implant inserted from the alveolar crest may have perforated, in the lingual direction, the slender female cortical bone and/or the residual ridge, the height and width of which had been resorbed following tooth loss. The serious bleeding on the floor of the mouth occurred in 4 cases in the male dentate group (Table 6).[2–16] This number is second to the 7 cases in the female edentulous group. The results of the current study may suggest that those serious incidents in the male dentate group are caused by perforation of the lingual cortical bone induced by the SF.

The LD in the sample with the deepest SF in the current study was 5.8 mm. All 32 SFs were vertically located above the mylohyoid line and horizontally located in the canine-premolar region. Of the past 16 clinical cases of critical haemorrhage on the floor of the mouth during implant placement, 11 also had the drilling/installation site in the canine or premolar region (Table 6).[2–7,9–11,14] Seven of the 16 cases involved perforation of the lingual cortical bone by an implant $\geq$15 mm in length (Table 6).[3,6,7,10,12–14] Mardinger et al.[20] measured the location of the lingual perimandibular vessels using 12 human cadavers. They[20] demonstrated that the blood vessels were identified above the mylohyoid muscle in the lingual mandibular canine area in 11 of the 12 cadavers. They also described the mean VD from the alveolar crest to the vessels as being 15.6 mm and the mean horizontal distance from the lingual cortical bone to the vessels as being 2.8 mm in the canine area.[20] Therefore, the location of the vessel identified by Mardinger et al.,[20] is adjacent to the location of the SF identified in the current study as well as to the implant site[2–7,9–11,14] of the life-threatening cases complicated by haemorrhage following the perforation of the lingual cortical bone during implant placement.

Hofschneider et al.[18] conducted a study to assess the vascular supply to the MIR using 17 human cadavers. They[18] found that these vessels course closely to the SF.

Loukas et al.[19] reported that perforating cortical branches (artery branches that enter the lingual foramen in the mandible) were found at an average height of 10.3 mm (5.6–18.9 mm) superior to the IMM. The average VD between the IMM and the B level, where the SF was located in the current study, was 12.5 mm (9.2–15.7 mm) in all samples and 11.5 mm (9.2–15.0 mm) in the edentulous group. The SF may approximate the perforating cortical branches entering the lingual foramen.

In all samples with the SF in the current study, the range and mean VD $\pm$ SD between the MF level and the B level were 2.2–6.1 mm and 4.1 $\pm$ 0.9 mm, respectively (Table 4). In the edentulous group, the range and mean VD $\pm$ SD were 2.2–4.7 mm and 3.7 $\pm$ 0.9 mm, respectively (Table 5). This information may be useful for oral and maxillofacial surgeons to infer the vertical location of the SF intraoperatively, using the MF as the anatomical landmark when approaching the MIR from the alveolus side for implant placement.

In this pilot study, the authors observed the SF directly in cadavers and obtained basic measurement data. The results with a limited number of subjects revealed certain

Table 6. Sixteen cases of serious bleeding on the floor of the mouth during or following mandibular interforaminal implant placement.

Reporting year		Age/gender	Dental status	Implant used	Site
1986	2	59/Female	Dentate	n/a	Canine
1990	3	54/Female	Edentulous	Brånemark, length: 18 mm, diameter: 3.75 mm	Canine
1990	4	67/Male	Edentulous	CoreVent, cylinder type	Canine
1993	5	58/Female	Edentulous	ITI, solid type	Canine
1993	5	42/Female	Edentulous	ITI, hollow cylinder type	1st premolar
1994	6	80/Female	Edentulous	IMZ, length: 15 mm, diameter: 4 mm	Canine
1997	7	69/Female	Edentulous	Brånemark, length: 15 mm, diameter: 3.75 mm	Canine
1997	8	72/Male	Edentulous	n/a	Symphysis
1999	9	42/Male	Dentate	n/a	Canine
2000	10	63/Female	Dentate	Length: 18 mm, diameter: 3.75 mm	Canine
2001	11	64/Female	Edentulous	n/a	Canine
2002	12	50/Male	Dentate	Length: 15 mm, diameter: 3.75 mm	Lateral incisor
2004	13	56/Male	Dentate	Length: 15 mm, diameter: 4.2 mm	Interforaminal
2005	14	43/Male	Dentate	Length: 15 mm, diameter: 4 mm	1st premolar
2006	15	80/Female	Edentulous	n/a	Interforaminal
2006	16	47/Female	Dentate	n/a	Central incisor

tendencies in the depth and location of the SF but the variation was extensive, indicating the necessity to identify it in each case as accurately as possible by CT before implant placement in the MIR to minimize the risk of sublingual bleeding/lingual cortical perforation. The authors are presently planning phase 2 of the study, in which the data will be compared with CT data obtained on the same subject to find some possible correlation between the anatomic and CT data that may be applied to CT image interpretation.

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None.

Competing interests

None.

Ethical approval

Given by the Ethics Committee at Saga Medical School.

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