Retrospective Radiographic Evaluation of the Anterior Loop of the Mental Nerve: Comparison Between Panoramic Radiography and Spiral Computerized Tomography

Yavuz Kaya, DDS, PhD[1]/Metin Sencimen, DDS, PhD[2]/Sermet Sahin, DDS, PhD[3]/
Kemal Murat Okcu, DDS, PhD[4]/Necdet Doğan, DDS, PhD[5]/Melike Bahcecitapar[6]

Purpose: *This study compares the prevalence and the length of mental loops, which were measured with panoramic radiographs and spiral computerized tomographs (SCT).* ***Materials and Methods:*** *Seventy-three panoramic radiographs and 73 SCTs were taken for preoperative planning of implant placement in the interforaminal region of the anterior mandible. The bone quality of both mental regions in each patient was determined by 1 experienced calibrated clinician, and the cross-sectional images of the SCTs were evaluted for bone quality according to the Lekholm and Zarb classification. Panoramic radiographs and cross-sectional SCT images were examined carefully by the same calibrated clinician to determine the presence and to measure the length of the mental loop in each patient. The relationship between these radiographs was also examined and correlated with bone quality. Paired samples* t *test and Pearson's correlations were used to examine the agreement between 2 radiographic methods at each bone quality. A 5% level of significance was chosen.* ***Results:*** *The prevalence of the mental loop in panoramic radiographs and spiral CT images was 28% and 34%, respectively. The mental loop was identified more frequently in spiral CT images regardless of bone quality. The demonstration of the mental loop between radiographic methods was more pronounced in poor bone quality. The mean length of the mental loop in panoramic radiographs was 3.71 ± 1.35 mm and 3.00 ± 1.41 mm in SCT. Measurements for panoramic radiographs were higher than those for spiral CT images. There was a correlation of r = 0.66 (*P *= .01) between the 2 radiographic methods, indicating agreement.* ***Conclusions:*** *SCT demonstrated a higher prevalence of mental loops than panoramic radiographs. SCT can be more useful to visualize and measure the mental loop in low bone qualities. Panoramic radiographs significantly overestimate (*P *= .02 in type 3,* P *= .01 in type 4) mental loop length, which were measured in spiral CT images in poor bone quality, but there is a close correspondence between these 2 radiographs in higher quality bone.* INT J ORAL MAXILLOFAC IMPLANTS 2008;23:919–925

Key words: *anterior loop, mental nerve, panoramic radiography, preoperative implant planning, spiral computerized tomography*

[1]Postdoctorate Researcher, Department of Periodontology, Dental Sciences Center, Gulhane Military Medical Academy (GMMA), Ankara, Turkey.
[2]Assistant Professor, Department of Oral and Maxillofacial Surgery, Dental Sciences Center, Gulhane Military Medical Academy (GMMA), Ankara, Turkey.
[3]Assistant Professor, Department of Periodontology, Dental Sciences Center, Gulhane Military Medical Academy (GMMA), Ankara, Turkey.
[4]Assistant Professor, Oral and Maxillofacial Surgery, Dental Sciences Center, Gulhane Military Medical Academy (GMMA), Ankara, Turkey.
[5]Associate Professor, Oral and Maxillofacial Surgery, Dental Sciences Center, Gulhane Military Medical Academy (GMMA), Ankara, Turkey.
[6]Statistician, Department of Statistics, Faculty of Science, Hacetteppe University, Ankara, Turkey.

Correspondence to: Dr Yavuz Kaya, Department of Periodontology, Dental Sciences Center, Gulhane Military Medical Academy, 06018, Etlik, Ankara, Turkey. E-mail: kayayavuz@gmail.com

Today, there are many diagnostic techniques aiding the clinician in presurgical planning of dental implants. Preoperative radiographic examination is an essential diagnostic method to determine the size, location, and angulation for each dental implant and to choose the number of implants to place.[1,2]

Examination of bone quality and quantity and relative anatomic structures, including the maxillary sinuses, nasal cavity, incisive canal, mandibular canal, and mental foramen, is paramount for successful implant therapy.[3–6] Two-dimensional imaging methods, including periapical, occlusal, cephalometric, panoramic radiography, and cross-sectional imaging, including different kinds of tomographies and magnetic resonance, are the radiographic methods of choice for preoperative evaluation.[1–3,7] Some authors claim that 2-dimensional radiographs can be enough for presurgical implant planning,[1,8] but the others believe there is a need for additional cross-sectional imaging.[7,9,10]

The important anatomic landmarks in the mandible are the mandibular canal, through which the inferior alveolar nerve passes, the mental foramen, and the mental nerve, which has an anterior loop (genu). The location of the mental foramina and the anterior loop of the mental neurovascular bundle determine the location of the most distal contralateral implants at interforaminal area.[5,6,11,12] Surgical trauma to the mental nerve is possible during the implant therapy and causes altered sensation of lower lip and chin.[13] Furthermore, direct damage to the incisive nerve may also cause sensory disturbances.[14]

There are conflicting reports on the frequency and length of the anterior loop of the mental nerve.[6,11,12,15–22] In these studies, the existence and the extent of forward-projecting genu were determined by periapical radiography,[12] panoramic radiography,[6,15,21] spiral computerized tomography (SCT),[18] direct measurement during the surgery,[17] or dissection in cadavers.[6,12,15,16,19–22]

One prominent feature of cross-sectional imaging is its capacity to give information about the buccolingual width of the alveolar bone.[2,3,11] Additionally determining the maxillary sinus floor[23] and the superior border of the mandibular canal has been shown to be more accurate in cross-sectional tomography than panoramic radiography.[4] However, hitherto none of the studies has assessed the difference in measurement of the mental loop between these 2 radiographic methods.

The aim of this in vitro radiographic validation study was to determine whether panoramic radiography (as opposed to SCT) would be sufficient to locate the mental canal in accordance with the ALARA principle (as low as reasonably achievable) regarding radiation exposure and to compare the length of the anterior loop of the mental nerve along with bone quality between these radiographic techniques.

MATERIALS AND METHODS

Seventy-three patients (39 female and 34 male) aged 18 to 68 years who were referred to the Department of Periodontology and Department of Oral and Maxillofacial Surgery, Gulhane Military Medical Academy (GMMA) for implant therapy in the interforaminal area from 2004 to 2006 were included in the study. Before starting implant surgery, the patients were subjected to complete radiographic examination consisting of panoramic radiography and SCT. All panoramic images were obtained using the same Panovra 10-C (Toshiba Panoramic X-ray Unit) orthopantomograph with CEA OGA screen film (CEA OGA AB, Strangnas, Sweden). The exposure factors were 55–65 kVp, 5–7 mA, 15 s time for panoramic radiography. SCT was performed with a 16-channel multidetector Philips MX8000 IDT (Philips Medical Systems, Best, Netherlands). SCT was used at 120 kV and 221 mA, with 0.5-s rotation time, with 1.6 × 0.75-cm rectangular collimator, 1.0-mm slice thickness. The data were transferred to a network computer workstation (Philips Extended Brillance Workspace 2.0.11; Philips Medical Systems). The film processing conditions were standardized by using a Kodak-2180 (Eastman Kodak, Rochester, NY) automatic developer.

Radiographic Measurement Procedure

All radiographs were measured by one of the authors (MS), who is a maxillofacial surgeon with previous experience in SCT, panoramic radiograph interpretation, and implant dentistry. Before the observation period, the guidelines for measurements were discussed, and the observer was calibrated in both radiographic systems to recognize the existence and the length of the mental loop. The borders of the object to be measured were well defined, and the observer was also aware of misinterpretation by both verbal and written instructions. In each patient, both contralateral mental regions were checked for mental loops. All examinations were performed on a standard radiologic view box with a lens displaying 4× magnification under standardized viewing conditions, and in each case, measurements were made to the nearest 0.5 mm with a transparent plastic ruler. When assessing a tomographic cross-sectional cut for the location of the mandibular or mental canal was difficult, the observer was allowed to look at the adjacent tomographic slices on the same radiograph but not at the panoramic or axial view of the SCT. The values obtained from the panoramic measurements were corrected for their magnification (divided by the enlargement factor 1.3) as defined by the manufacturers. SCT images were in their actual size (ratio 1:1). Measurement of the length of the mental loop was repeated 2 weeks later to evaluate the reproducibility of the recordings. The examiner took the second set of measurements without having access to the initial set.

If an anterior loop was observed on the panoramic radiograph, the extent of the anterior loop of the mental canal was measured by measuring the shortest distance from the 2 lines drawn passing through the most anterior point of both the mental foramen and the mental canal, as described by Kuzmanovic et al (Fig 1).[6] If an anterior mental loop was observed on the SCT, the extent of the anterior loop was measured by counting the first and last cross-sectional 1.0-mm-thick slices in which the

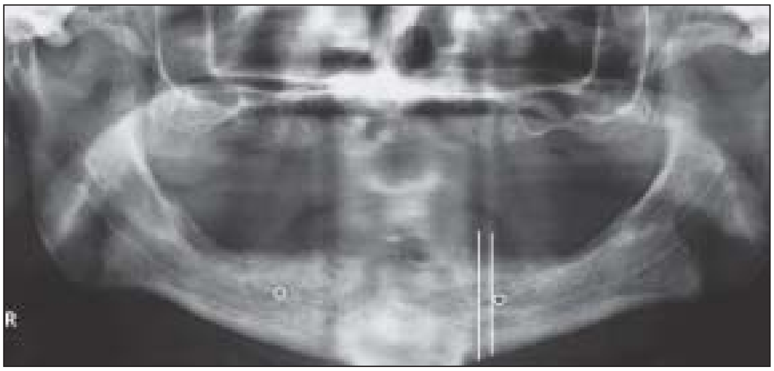

Fig 1 *(Right)* Mental foramen and mandibular and mental canals have indistinct borders in type 4 bone quality, which makes measurement of the mental loop difficult on a panoramic radiograph.

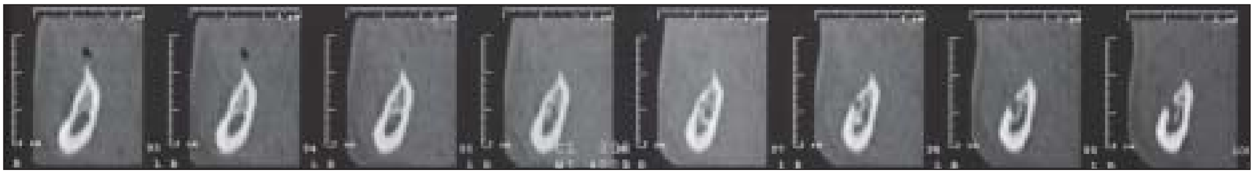

Fig 2 *(Below)* SCT of the same patient shown in Fig 1. Anterior loop of the mental nerve appears in cross sections 93 through 98, nerve exits in cross sections 99 through 100. Loop has a "figure 8" shape with the mandibular canal.

mandibular and mental canals were seen together or attached like a "figure 8" (Fig 2).[11] Care was taken to exclude the last slice of mental foramen opening to the external cortex and the first slice of the small incisive channel for the mandibular anterior teeth, which is narrower than the mandibular canal.[11,18]

Bone Quality Evaluation

The bone quality of the mandibular anterior region was subjectively classified by cross-sectional images of the SCT according to the Lekholm and Zarb[24] classification in both of the mental nerve regions in each patient by the same author (MS).

Data and Statistical Analysis

For all statistical calculations, SPSS 10.0 software (SPSS, Chicago, IL) was used. The intraobserver reproducibility of the measurements was expressed as the difference between duplicate recordings and was assessed using kappa statistics. If the measurements were not duplicated, the mean of both values was used for data analysis. If a mental loop was observed in both radiographic methods, measurements were made and mean differences were calculated for each and for all bone qualities.

Agreement between panoramic and SCT radiographs was assessed in 2 ways. Absolute agreement was estimated by comparing the mean difference with a paired samples *t* test, and then Pearson correlations were used to examine the relative agreement between 2 radiographic methods at each bone quality. *P* values less than .05 were considered significant.

RESULTS

The intraobserver reproducibility of the initial measurements made in PR and SCT as evaluated from duplicate, 2-week-apart measurements are presented in Table 1. In 72% of panoramic and 66% of spiral images, the mental loop could not be determined. Only 8% and 2% of the PR and SCT measurements were deviated more than 1 mm, respectively. The results of Kappa statistics showed 0.36 ($P = .02$) and 0.42 ($P = .01$) reproducibility for panoramic radiography and SCT, respectively.

The prevalence of the mental loop in quality types 1 through 4, which was determined in both radiographs, was 24%, 24%, 14%, and 17%, respectively (Fig 3). In all bone qualities more mental loops were determined in SCT than panoramic radiography.

Table 2 shows that the length of the mental loop was measured to be 0.71 ± 0.21 mm greater in the panoramic radiographs than the SCT images ($P = .014$). In all bone qualities there was an overestimation in mental loop measurements on the panoramic radiographs when compared with SCT. The highest overestimation was seen in type 4 bone (1.11 ± 0.52 mm, $P = .01$), the lowest in type 1 (0.22 ± 0.25 mm, $P > .05$).

The correlation between radiographic methods ranged from $r = 0.41$ in type 4 ($P = .031$) to $r = 0.83$ in type 1 ($P = .01$), indicating relative agreement, especially in types 1 and 2 bone (Table 3).

Table 1 Reproducibility of Measurements of the Length of the Mental Loop in Panoramic Radiography and SCT

Difference between duplicate measurements	Panoramic		SCT	
	n	%	n	%
Indeterminable/lack of mental loop	105	72	96	66
Perfect concordance (± 0 mm)	15	10	21	14
± 0.5 mm	9	6	14	10
± 1 mm	6	4	11	8
± 1.5 mm	4	3	2	1
± 2 mm	3	2	2	1
± 2.5 mm	3	2	0	0
± 3 mm	1	1	0	0
Total	146	100	146	100

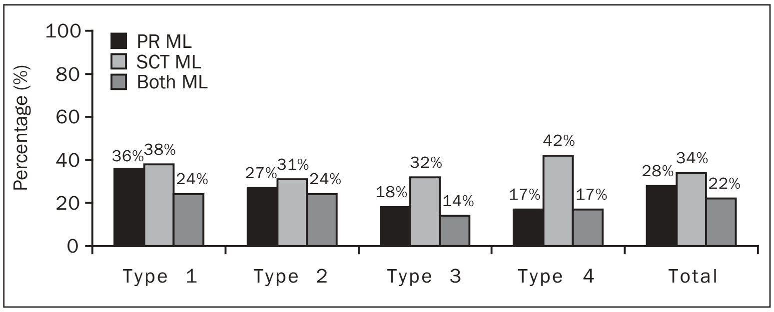

Fig 3 The prevalence (%) of determined mental loop (ML) in panoramic radiography (PR), spiral computerized tomography (SCT), or both radiographs in different bone qualities.

Table 2 Comparison of Average Measurements of Mental Loop in mm from Panoramic Radiography and SCT by Bone Quality

	Panoramic		SCT		PR–SCT		
Bone quality	Mean	SD	Mean	SD	Mean	SD	*P*
Type 1	3.51	1.25	3.29	1.52	0.22	0.25	NS
Type 2	3.63	1.81	3.16	1.30	0.47	0.19	NS
Type 3	3.82	1.46	2.78	1.96	1.04	0.65	.028
Type 4	3.91	0.54	2.80	0.61	1.11	0.52	.010
All	3.71	1.35	3.00	1.41	0.71	0.21	.014

NS = not significant.

Table 3 Relative Agreement of Mental Loop Length Between Measurements with Panoramic Radiography and SCT by Bone Quality

Bone quality	n	*r*	*P*
Type 1	12	0.83	.010
Type 2	15	0.88	.027
Type 3	3	0.53	.022
Type 4	2	0.41	.031
All	32	0.66	.018

n = number of loops determined in both radiographs; *r* = relative agreement.

DISCUSSION

Before the implant surgery in the interforaminal region, radiographic examination is necessary to identify mental foramen, mental loop, and available bone quality and quantity. Locating mental foramen and its genu is essential to avoid neurologic deficits.[13] During preoperative implant planning, 2-dimensional panoramic radiography is routinely used to locate these anatomic landmarks. Tomographs are usually used to determine available bone quality and volume in buccolingual dimensions but not usually to locate mental foramen or its anterior loop.[3,11,13]

Some studies have suggested that the length of the anterior loop cannot be measured with panoramic radiography unless the mental canal is connected to the mandibular canal[6,25] or that it can be confused with the large incisive canal in computerized tomographs.[13] In other studies, not only the mental loop but also the incisive canal was determined by panoramic radiography[22] and SCT.[18] The present study compared the use of panoramic radiography and SCT to determine and measure the length of the mental loop.

Radiographic measurements were repeated in order to calculate the intraobserver error. Intraobserver reproducibility showed that repeated measurements were more accurate in SCT ($\kappa = 0.42$) when compared with panoramic radiography ($\kappa = 0.36$; Table 1). Deviation of 2.5 to 3 mm could be seen in panoramic radiography even though an experienced, calibrated clinician made all measurements. The radiographic determination of the anterior loop in panoramic radiography can be adversely affected by showing no connection with the mandibular canal and poor bone quality.[6] Radiopaque structures, especially superimposition of cervical spines in the anterior region, may hide the loop in panoramic images.[26] But in buccolingual cross-section images of SCT, this deviation remained 2 mm at most. This may be the result of the pre-eminent ability of SCT to show the boundaries of the mandibular canal, mental foramen, and anterior loop more clearly in patients of all ages and both genders.[18] Kuzmanovic et al[6] reported a perfect intraobserver and interobserver agreement with panoramic radiography for measuring the length of the mental loop. In contrast, Lindh et al[4] showed a clear interobserver deviation when measuring the distance between the alveolar crest and the mandibular canal in panoramic measurement and concluded that the tomographic images were more accurate than panoramic images.

In previous reports, there were clear distinctions in the prevalence of the mental loop. This prevalence varied between none and 94%.[15,19] Kieser et al[19] and Rosenquist[17] stated that this wide range in the results of studies may be due to linear measurement of the 3-dimensional mental nerve. They stated that the mental loop is usually an artifact that actually does not exist. In the study presented here, the prevalence of the mental loop in panoramic radiography, SCT, and both radiographs were 28%, 34%, and 21%, respectively. The results of Kuzmanovic et al,[6] Rosenquist,[17] and Mardinger et al,[12] who reported low prevalence of the anterior loop, were in agreement with the present findings; Jacobs et al[18] reported the presence of the mental loop to be 11% with panoramic radiography, which was lower than our results. The differences in the prevalence of the anterior loop in their study and the present study may be explained by difference in bone quality. In good bone quality, the mental canal walls can easily be seen by well-defined cortical borders in both radiographs. In the present study, the mental loop was less prominent in type 4 bone, which is in accordance with Jacobs et al.[18]

In types 1 and 2 bone, both radiographs determined similar prevalence of mental loop, but in type 4 bone the prevalence of mental loop was much higher in SCT images (Fig 3). This can be the result of the CT capability to show the cortical margins of the neurovascular bundle more clearly when compared with other tomographs and panoramic images even in poor bone quality (Figs 1 and 2).[4] However, narrow tomographic slices may not provide sufficient contrast to determine thin cortical walls despite the high dose of radiation given.[3] Nevertheless, 2-dimensional images such as periapical and panoramic radiography have evident deficiencies, depending on patient position (projection geometry)[3,9,14] and corticalization quantity of the canal wall.[4,14] The prevalence of mental loop, which was determined with both radiographs, was prominently lower in poor bone qualities. Anderson et al[27] reported that as the inferior alveolar nerve approaches the foramen mentale, the decrease in the definite bone walls of the mandibular canal can affect panoramic measurements.

Previous studies have also shown significant variation of the length of mental genu ranging from 0.5 mm to 1 cm.[11–17] This wide variation in results may be related to case selection and diagnostic techniques.[19–21] In all bone qualities evaluated in the present study, the mean length of the anterior loop mental nerve was 3.71 mm and 3.00 mm in panoramic radiography and SCT, respectively. This is congruent with Arzouman et al[15] who reported 3.18 mm (Panelipse, Gendex Dental Systems, IL) and more than Kuzmanovic et al,[6] who noted 1.50 mm (Soredex, Orion Corporation, Helsinki, Finland) mental loop length in panoramic images. Bavitz et al[16] found maximum mental loop length to be 1 mm, Mardinger et al[14] reported 2.19 mm, and Kuzmanovic et al[6] reported 1.20 mm mental loop length in cadaveric samples, which differs from the SCT measurements in the present study in all bone qualities. In a study performed to determine the vulnerability of the mental nerve during genioplasty in 80 Korean cadavers, Hwang et al[21] reported a 5-mm anterior loop, which is longer than the measurements presented here.

Results showed that there was good correlation between these radiographs, especially in types 1 and 2 bone qualities, which have radiographically prominent corticalized canal walls, indicating a close correspondence (Table 3). Nevertheless, the mean difference between these measures is statistically significant in poor bone qualities. Reddy et al stated[9] that there is still an error in both planes even after the magnification correction of manufacturer information, with more significant changes in the horizontal plane. Both methods measure the mental loop length; however, panoramic radiography had consistently higher readings (Table 2). This may be the result of the magnification in the vertical plane, especially in the anterior region,[3,6,9] and nonuniform magnification, especially in the horizontal plane, which is highly variable in the panoramic radiography despite correction for magnification.[3,7,9] Serhal et al,[28] who measured the distance between the alveolar crest and the mental foramen by panoramic, spiral tomographs, and computerized tomographic (CT) images, reported that panoramic images showed more deviation from the perioperative measurements than tomographs and overestimated the distance because of patient positioning or inadequate ability in locating the foramen.

The bone density classification system proposed by Lekholm and Zarb[24] was a scoring system based on cross-sectional radiographic assessment.[7] This classification has been modified to evaluate bone density during drilling by tactile sensation.[29] Both of these methods have been accepted as subjective classification systems, and the need for objective evaluation was met by CT axial images evaluated by quantitative data called Hounsfield units.[29] But this quantitative bone density measurement cannot differentiate types 2 and 3 bone qualities clearly and can be impractical for use in every patient.[30,31] There is a significant correlation found between subjective cross-sectional classification and Hounsfield units, especially in type 1 and type 4 bone qualities,[30,31] so the authors prefer to evaluate bone density practically with the Lekholm and Zarb[24] classification system in cross-sectional SCT images.

The results of the present study indicate that intraobserver deviation is higher with panoramic radiography (Table 1) and that there is significant overestimation in mental loop length measurements when compared with SCT images, especially in poor bone qualities (Table 2). The prevalence of the mental loop is less in panoramic radiographs with poor bone qualities, maybe because of less corticalized canal walls leading to an undefined mental loop, but this insufficency can be solved by taking SCT images in these patients for accurate evaluation. Poor bone qualities are less prevalent in the anterior mandibular region,[29] so SCT images can be unnecessary for assessing the mental loop because similar results are obtained with panoramic radiographs in bone types 1 and 2, thus conforming to ALARA principle.

In conclusion, in poor bone qualities, taking only a panoramic radiograph may cause the mental loop not to be determined or its length to be overestimated when compared with SCT. Overestimating the length will not cause any significant problem, but taking only a panoramic radiograph may cause the mental loop to be missed, leading to surgical trauma and altered sensation.

ACKNOWLEDGMENTS

The authors thank Mrs Melike Bahcecitapar at Hacettepe University, Faculty of Science, Department of Statistics for her statistical support in analyzing the data.

REFERENCES

1. Harris D, Buser D, Dula K, et al. EAO Guidelines for use of diagnostic imaging in implant dentistry. A consensus workshop organized by the European Association for Osseointegration in Trinity Dublin. Clin Oral Implants Res 2002;14:464–471.
2. Kircos LT, Misch CE. Diagnostic imaging and techniques. In: Misch CE (ed). Comtemporary Implant Dentistry. St Louis: Mosby, 1993:73–87.
3. Frederiksen NL. Diagnostic imaging in dental implantology. Oral Surg Oral Med Oral Pathol 1995;80:540–554.
4. Lindh C, Petersson A, Klinge B. Measurements of distances related to the mandibular canal in radiographs. Clin Oral Implants Res 1995;6:96–103.
5. Serhal CB, Steenberghe DV, Quirynen M, Jacobs R. Localization of the mandibular canal using conventional spiral tomography: A human cadaver study. Clin Oral Implants Res 2001;12: 230–236.
6. Kuzmanovic DV, Payne AGT, Kieser JA, Dias GJ. Anterior loop of the mental nerve: A morphological and radiographic study. Clin Oral Implants Res 2003;14:464–471.
7. Tyndall DA, Brooks SL. Selection criteria for dental implant site imaging: A position paper of American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol 2000; 89:630–637.
8. Frei C, Buser D, Dula K. Study on the necessity for cross-section imaging of the posterior mandible for treatment planning of standard cases in implant dentistry. Clin Oral Implants Res 2004;15:490–497.
9. Reddy MS, Mayfield-Donahoo T, Vanderven FJJ, Jeffcoat MK. A comparison of the diagnostic advantages of panoramic radiography and computed tomography scanning for placement of root form dental implants. Clin Oral Implants Res 1994;5: 229–238.
10. Schropp L, Wenzel A, Kostopoulos L. Impact of conventional tomography on prediction of the appropriate implant size. Oral Surg Oral Med Oral Pathol 2001;92:458–463.
11. Rothman SLG. Computerized tomography of the mandible. In: Rothman SLG. Dental applications of computerized tomography: Surgical planning for implant placement. Chicago: Quintessence, 1998:39–64.
12. Mardinger O, Chaushu G, Arensburg B, Taicher S, Kaffe I. Anterior loop of the mental canal: An anatomical-radiologic study. Implant Dent 2000;9:120–123.

13. Kraut RA, Chahal O. Management of patients with trigeminal nerve injuries after mandibular implant placement. J Am Dent Assoc 2002;133:1351–1354.
14. Mardinger O, Chaushu G, Arensburg B, Taicher S, Kaffe I. Anatomic and radiologic course of the mandibular incisive canal. Surg Radiol Anat 2000;22:157–161.
15. Arzouman JM, Otis L, Kipnis V, Levine D. Observation of the anterior loop of the inferior alveolar canal. Int J Oral Maxillofac Implants 1993;8:295–300.
16. Bavitz BJ, Ham DS, Hansen AC, Lang M. An anatomical study of mental neurovascular bundle-implant relationship. Int J Oral Maxillofac Implants 1993;8:563–567.
17. Rosenquist B. Is there an anterior loop of the inferior alveolar nerve? Int J Periodontics Restorative Dent 1996;16:41–45.
18. Jacobs R, Mraiwa N, van Steenberghe D, Gijbels F, Quirynen M. Appearance, location, course, and morphology of the mandibular incisive canal: An assessment on spiral CT scan. Dentomaxillofacial Radiol 2002;31:322–327.
19. Kieser J, Kuzmanovic D, Payne A, Dennison J, Herbison P. Patterns of emergence of human mental nerve. Arch Oral Biol 2002;47:743–747.
20. Nevia RF, Gapski R, Wang HL. Morphometric analysis of implant-related anatomy in caucasian skulls. J Periodontol 2004;75:1061–1067.
21. Hwang K, Lee WH, Song YB, Chung IH. Vulnerability of the inferior alveolar nerve during genioplasty: An anatomic study. J Craniofac Surg 2005;16:10–14.
22. Jacobs R, Mraiwa N, Steenberghe DV, Sanderink G, Quirynen M. Appearance of the mandibular incisive canal on panoramic radiographs. Surg Radiol Anat 2004;26:329–333.
23. Serhal CB, Jacobs R, Persoons M, Hermans R, van Steenberghe D. The accuracy of spiral tomography to assess bone quantity for preoperative planning of implants in posterior maxilla. Clinical Oral Implants Res 2000;11:242–247.
24. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark, P-I, Zarb GA, Albrektsson T (eds). Tissue-Integrated Prostheses: Ossseointegration in Clinical Dentistry. Chiago: Quintessence,1985:199–209.
25. Yosue T, Brooks LS. The appearance of mental foramina on panoramic radiographs. I. Evaluation of patients. Oral Surg Oral Med Oral Pathol 1989;68:360–364.
26. Schiff T, D'Ambrosio J, Glass BJ, Langlais RP, McDavid WD. Common positioning and technical errors in panoramic radiography. J Am Dent Assoc 1986;113:422–426.
27. Anderson LC, Kosinski TF, Mentag PJ. A review of the intraosseous course of the nerves of the mandible. J Oral Implantol 1991;17:394–403.
28. Serhal B, Jacobs R, Flygare L, Quirynen M, Steenberghe, DV. Preoperative validation of localisation of the mental foramen. Dentomaxillofac Radiol 2002;31:39–43.
29. Misch CE. Bone density: A key determinant for clinical success. In: Misch CE (ed). Comtemporary Implant Dentistry. St Louis: Mosby, 1993:109–118.
30. Norton MR, Gamble C. Bone classification: An objective scale of bone density using the computerized tomography scan. Clin Oral Implants Res 2001;12:79–84.
31. Shahlaie M, Gantes B, Schulz E, Riggs M, Crigger M. Bone density assessments of dental implant sites: 1. Quantitative computed tomography. Int J Oral Maxillofac Implants 2003;18:224–231.