Correlation of Radiographic Signs, Inferior Dental Nerve Exposure, and Deficit in Third Molar Surgery

Yiu Yan Leung, BDS, MDS, and Lim Kwong Cheung, BDS, PhD†*

Purpose: To identify the specific radiographic signs on orthopantomograms that are positive predictors of intraoperative inferior dental nerve (IDN) exposure and postoperative IDN deficit in lower third molar surgery.

Materials and Methods: A prospective clinical cohort of patients with lower third molars with specific radiographic signs showing a close proximity of the roots to the IDN who underwent total excision at our center from June 2006 to June 2008 were recruited as the study group. The prevalence of intraoperative IDN exposure and postoperative IDN deficit were recorded. The correlations between the various radiographic signs and the prevalence of IDN exposure and deficit were analyzed. The prevalence of IDN deficit in the sample was compared with an age-, gender-, and operator experience-matched control group of patients who had undergone lower third molar surgery without any of the radiographic signs present.

Results: Patients with a total of 178 lower third molars with 1 or more of the specific radiographic signs present were recruited as the study group. The prevalence of IDN deficit in the study group (5.1%) was significantly greater than that in the control group (0.56%; $P = .01$). In the study group, darkening of root and displacement of the inferior dental canal by the root were radiographic signs significantly related to IDN exposure ($P = .001$ and $P = .019$, respectively). Darkening of the root was the only sign significantly related to a postoperative IDN deficit ($P = .016$). When 2 or more radiographic signs were present, the risk of a postoperative IDN deficit was significantly increased ($P = .001$).

Conclusions: Darkening of the root and displacement of the inferior dental canal by the root were positive predictors of intraoperative IDN exposure. Darkening of the root or the presence of 2 or more radiographic signs were positive predictors of a postoperative IDN deficit.

J Oral Maxillofac Surg 69:1873-1879, 2011

Third molar surgery is the most common surgical procedure in the oral cavity. However, lower third molar surgery has been associated with the risk of inferior dental nerve (IDN) injury that results in paresthesia of the lower lip region and significantly affects patients' quality of life.[1-6] The close proximity of the roots of a lower third molar to an inferior dental canal (IDC) is the most direct cause of IDN deficit from trauma to the nerve during the surgery. Radiologic imaging is the only method available to detect this intimate relationship. A plain radiograph such as an orthopantomogram can only provide a 2-dimensional image. If it shows the root of the third molar overlapping with the IDC that harbors the IDN, clinicians must judge its true 3-dimensional relationship using hints from various radiographic signs. Several studies have indicated that specific radiographic signs are associated with intraoperative IDN exposure.[7-9] The prediction of intraoperative IDN exposure would be very useful for clinicians to explain the increased risk of IDN deficit to patients and to avoid apical pressure during root elevation or even to perform multiple sectioning of the tooth to reduce any stress to a root on elevation. Such clinical judgment is of great clinical significance to minimize the risk of IDN deficit by advising patients not to undergo wisdom tooth removal, to choose an alternative technique such as coronectomy, or to order advanced 3-dimensional imaging, such as cone-beam computed tomog-

Received from Discipline of Oral and Maxillofacial Surgery, Faculty of Dentistry, The University of Hong Kong, Hong Kong, People's Republic of China

*PhD Candidate.

†Chair Professor.

Address correspondence and reprint requests to Prof Cheung: Department of Oral and Maxillofacial Surgery, Prince Philip Dental Hospital, 34 Hospital Rd, Hong Kong, People's Republic of China; e-mail: lkcheung@hkucc.hku.hk

0278-2391/11/6907-0012$36.00/0
doi:10.1016/j.joms.2010.11.017

FIGURE 1. Darkening of third molar root.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

raphy. Three-dimensional imaging is considered more precise in predicting the relationship of IDN and third molar root; however, it is not readily available in general dental practices and far more expensive than plain radiographs that the average patient can afford.[10,11] To our knowledge, no study has shown that 3-dimensional imaging is superior to plain radiographs in preventing postoperative IDN deficit after third molar surgery.

The hypothesis of the present study was that the risks of intraoperative IDN exposure and postoperative IDN deficit would be increased in third molar surgery in the presence of specific radiographic signs relating the roots to the IDC. Hence, the aims of the present study were to identify the specific radiographic signs from the orthopantomogram (OPG) that are positive predictors of intraoperative IDN exposure and postoperative IDN deficit during lower third molar surgery.

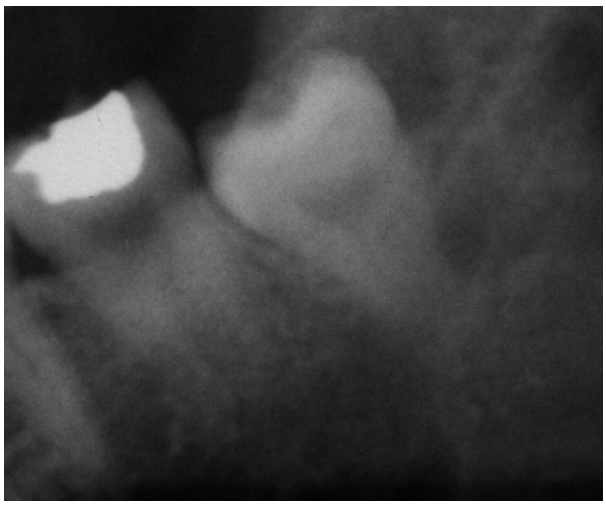

FIGURE 2. Abrupt narrowing of wisdom tooth root.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

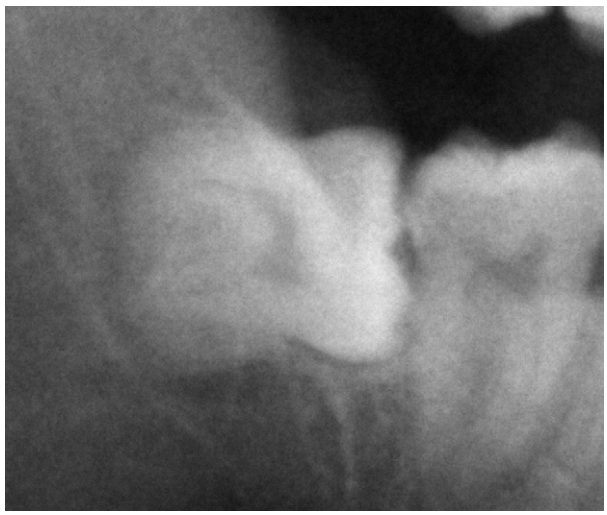

FIGURE 3. Interruption and loss of white line representing IDC.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

Materials and Methods

STUDY DESIGN/SAMPLE

The present prospective clinical cohort study recruited patients presented to the Discipline of Oral and Maxillofacial Surgery, University of Hong Kong Faculty of Dentistry, from June 2006 to June 2008 for surgical removal of the lower third molars if the third molars showed close proximity to the IDN radiographically. Patients were included in the present study if their OPG showed 1 or more of the following radiographic signs:

1. Darkening of the third molar root (Fig 1)
2. Abrupt narrowing of the third molar root (Fig 2)
3. Interruption and loss of the white line representing the IDC (Fig 3)
4. Displacement of the IDC by the third molar root (Fig 4)
5. Abrupt narrowing of 1 or both of the white lines representing the IDC (Fig 5)

Patients with a pre-existing IDN deficit or any pathologic finding (cystic or neoplastic) associated with the lower third molars were excluded from the present study.

The subjects included in the present study were patients recruited as the control group (total excision of a third molar) for a randomized controlled trial

FIGURE 4. Displacement of IDC by third molar root.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

comparing coronectomy and total excision of third molars.[12] The Institutional Review Board of the University of Hong Kong/Hospital Authority, Hong Kong West Cluster approved the study. All participants provided study consent.

Preoperatively, the details of the patients and third molar status were recorded according to a standardized protocol, including age and gender, eruption status, impaction pattern, and depth of impaction of the third molars according to Winter's line, and the presence of 1 or more of the 5 radiographic signs listed. The neurosensory baselines of the IDN were recorded using a neurosensory protocol, which noted the presence of self-reported subjective sensory changes of the lower lip and chin on the affected site and objective neurosensory measurements, such as light touch threshold, pain threshold, and 2-point discrimination, of both sides of the lower lip and chin region. The modes of anesthesia used during third molar surgery were also recorded.

Intraoperatively, the operators were asked to inspect the extraction socket with copious irrigation and careful suction after surgical removal of the lower third molar to check on the presence of IDN exposure, with the findings noted in the operation records. Exposure of the IDN was defined as a tubular whitish soft tissue structure running in an anteroposterior direction at the level, the third molar socket consistent with the OPG as suggested by Tay and Go.[13]

The patients were reviewed in the outpatient clinic at the first postoperative week and months 1, 3, 6, 12, and 24. The presence of IDN deficit was recorded using the neurosensory protocol. An IDN deficit was considered present if the subjective and objective measurements were both different from those on the nonaffected side or at baseline preoperatively.

The patients recruited to the present study with positive radiographic signs were categorized as the "study group." A "control group" was created from the patients recruited to another prospective study of neurosensory deficit after third molar surgery at our center[14]; these patients did not have any of the 5 radiographic signs listed. These patients were matched by age, gender, and operator experience and then randomly selected by drawing lots. The purpose of the control group was to compare any differences of IDN deficit risk after third molar surgery between those with and without positive radiographic signs of a close proximity of the roots to the IDC.

SURGICAL OVERVIEW

The procedures were performed with the patient under general anesthesia, using intravenous sedation with local anesthesia, or using local anesthesia alone. A buccal mucoperiosteal flap was raised to expose the impacted third molar. The lingual flap was not raised, but the lingual aspect was protected with a periosteal elevator. Sufficient buccal bone was removed with a round bur. Sectioning of the tooth with a fissure bur was performed, if required. The tooth was then elevated. Copious irrigation of the extraction socket with normal saline and a careful inspection of the socket base for any presence of the IDN were made. No foreign body or hemostatic agent was placed in the depth of the socket. The wound was then primarily closed with resorbable sutures.

OUTCOME VARIABLES

The primary outcomes of the study were the prevalence of an IDN deficit and the IDN exposure rate in

FIGURE 5. Abrupt narrowing of 1 or both of white lines representing IDC.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

the presence of the various radiographic signs. The secondary outcomes were the difference in the risk of the IDN deficit between the study and control groups, and the correlation of the IDN deficit with the radiographic signs around the third molar roots and IDCs in the study group.

STATISTICAL ANALYSIS

The data were analyzed using the Statistical Package for Social Sciences, version 15.0 (SPSS, Chicago, IL). Chi-square tests were used to compare the presence of intraoperative IDN exposure and IDN deficit with the various radiographic signs and the number of presented radiographic signs and to compare the incidence of IDN deficit with the patients' gender, tooth status, and IDN exposure. The *t* test was used to compare the incidence of IDN deficit and patient age. A 5% probability level was taken as the cutoff for statistical significance.

Table 1. CHARACTERISTICS OF WISDOM TEETH IN STUDY AND CONTROL GROUPS

Variable	Study Group (%)	Control Group (%)
Eruption status		
Erupted	1.1 (2/178)	8.4 (15/178)
Partially, erupted	55.6 (99/178)	72.5 (129/178)
Unerupted	44.3 (77/178)	19.1 (34/178)
Pattern of impaction		
Vertical	12.9 (23/178)	10.7 (19/178)
Horizontal	50 (89/178)	18 (32/178)
Mesioangular	32.6 (58/178)	64 (114/178)
Distoangular	4.5 (8/178)	7.3 (13/178)
Winter's line (mm)		
0–4	23.6 (42/178)	35.4 (64/178)
5–9	48.9 (87/178)	54.5 (97/178)
10–14	25.3 (45/178)	10.1 (18/178)
>15	2.2 (4/178)	0

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

Results

In the study group, 178 lower third molars in 118 patients were surgically removed during the study period. Of the 118 patients, 45 were male and 73 were female. The age range was 17 to 59 years (mean 26.2 ± 6.3). The control group was matched by gender and age and had the same basic demographics as the study group. The distribution of the eruption status and pattern and depth of impaction of the third molars in the study group and control group are listed in Table 1. The prevalence of an IDN deficit in the study group was 5.1% (9 of 178), significantly greater than that in the control group at 0.56% (1 of 178; $P = .01$).

In the study group, 117 (65.7%) of the 178 third molars had only 1 of the 5 radiographic signs, 49 (27.5%) had 2 signs, 9 (5.1%) had 3 signs, and 3 (1.7%) had 4 signs. No teeth presented with all 5 radiographic signs. The proportion of operations performed using local anesthesia and general anesthesia was similar at 48.3% (86 of 178) and 47.2% (84 of 178), respectively; the remaining (4.5%) were performed under local anesthesia and sedation. The operators identified IDN exposure after third molars removal in 24 (13.5%) of the 178 operations. All were reported intact clinically after careful inspection.

The mean patient age of those with an IDN deficit was 36.1 ± 10.5 years, which was significantly older statistically than that of the non-IDN deficit group (mean age 25.6 ± 5.6 years; $P < .001$). No statistically significant difference was found in the incidence of a nerve deficit by gender ($P = .27$). Also, no statistically significant differences were found in the IDN deficit in terms of eruption status of the tooth ($P = .099$) or the pattern of impaction ($P = .77$). The prevalence of an IDN deficit stratified by the depth of impaction was 0% (0 of 42), 4.6% (4 of 87), 6.7% (3 of 45), and 50% (2 of 4) at 0 to 4, 5 to 9, 10 to 14, and greater than 15 mm, respectively. The deeper the tooth impaction, the greater was the IDN deficit prevalence ($P < .001$). The prevalence of the IDN deficit when the IDN was exposed after third molar extraction was 20.8% (5 of 24), much greater than the 2.6% (4 of 154) prevalence in the group without IDN exposure. This difference was of high statistical significance ($P = .003$).

The correlation of the 5 radiographic signs with IDN exposure and deficit was analyzed (Table 2). It was noted that the radiographic signs "darkening of the third molar root" and "displacement of the IDC by the third molar root" were positive prediction markers of IDN exposure ($P = .001$ and $P = .019$, respectively). "Darkening of the third molar root" was the only radiographic sign that showed an increased risk of IDN deficit after third molar surgery ($P = .016$). The positive predictive value of IDN deficit with "darkening of the root" as the radiographic sign was 12% (6 of 50) and the negative predictive value was 97.7% (125 of 128). The sensitivity and specificity was 66.7% (6 of 9) and 74% (125 of 169), respectively. The risk of an IDN deficit was greater when the third molar presented with 2 or more of the 5 radiographic signs (Table 3). This finding was also of statistical significance ($P = .001$). The positive and negative predictive values of IDN deficit of the third molar with 2 or more radiographic signs were 11.7% (7 of 60) and 98.3% (116 of 118), respectively. The sensitivity and specificity were 77.8% (7 of 9) and 68.6% (116 of 169), respectively.

Table 2. RADIOGRAPHIC SIGNS IN RELATION TO IDN EXPOSURE AND IDN DEFICIT IN STUDY GROUP

Radiographic Sign	IDN Exposure (%)			IDN Deficit (%)		
	Yes	No	*P* Value	Yes	No	*P* Value
Darkening of third molar root	29.2 (14/50)	8.1 (10/128)	.001	12 (6/50)	2.3 (3/128)	.016
Abrupt narrowing of third molar root	20 (1/5)	13.3 (23/173)	.52	20 (1/5)	4.6 (8/173)	.23
Interruption and loss of white line representing IDC	13.8 (23/167)	9.1 (1/11)	.55	5.4 (9/167)	0 (0/11)	.56
Displacement of IDC by third molar root	30.4 (7/23)	11.0 (17/155)	.019	4.3 (1/23)	5.2 (8/155)	.67
Abrupt narrowing of 1 or both white lines representing IDC	11.1 (1/9)	23.6 (23/169)	.65	0 (0/9)	5.3 (9/169)	.62

Abbreviations: IDN, inferior dental nerve; IDC, inferior dental canal.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

Discussion

Radiography is no doubt the most useful method to use to predict the risk of IDN deficit after third molar surgery. Advances in dental radiography have been significant in the past decade, with the popularization of cone-beam computed tomography. It has been shown that the prediction of IDN exposure is superior with cone-beam computed tomography than with OPG.[10,15] However, OPG is still the most common radiographic tool for third molar assessment in dental practice,[9,11] owing to its lower cost, greater availability, and low radiation exposure.[16]

IDN exposure has been considered a significant risk factor for the occurrence of a postoperative IDN deficit.[7,13] Tay and Go[13] demonstrated a 20% IDN deficit in their prospective study when the IDN was exposed during surgery. Bell[7] did not find such a relationship, because none of the patients in his study with IDN exposure experienced a postoperative IDN deficit. Our results concur with those from Tay and Go,[13] because about one fifth (20.8%) of the subjects with intraoperative IDN exposure reported a postoperative IDN deficit. This can be explained by the possible direct trauma from the surgical elevators or indirect trauma from root dislodgement or lack of bone protection.

Table 3. NUMBER OF RADIOGRAPHIC SIGNS AND IDN DEFICIT RATE IN STUDY GROUP

Radiographic Signs (n)	IDN Deficit Rate (%)
1	1.1 (2/118)
2	12.2 (6/49)
3	12.5 (1/8)
4	0 (0/3)

$P = .001$.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

An IDN deficit was noted in a small percentage of subjects in the control group, which had no radiographic signs of close proximity of the third molar roots and IDN. It was believed the injury to the nerve could possibly result from compression of the roof of the IDC by the root from the rotational movement that occurred when it was elevated. If the root was fractured during the surgery, and the operator tried to retrieve it using a rotary instrument, the nerve could still be injured, even it was not in close proximity to the root.

Researchers have tried to correlate the various radiographic signs with IDN exposure to predict the risk of IDN deficit. Howe and Poyton[4] suggested that 93% of third molars showing darkening of roots radiographically have a true relationship with the IDN. Bell[7] showed an 11% and a 52% risk of IDN exposure in third molars removal with interruption of the IDC white line and darkening of the roots on the radiograph, respectively. Sedaghatfar et al[9] found a statistically significant association with 4 radiographic signs, darkening of root, narrowing of root, interruption of IDC white line, and diversion of IDC, with the risk of intraoperative IDN exposure. In our study, we found that darkening of the third molar root and displacement of the IDN canal by the third molar root to have significant risk of IDN exposure, with darkening of the root presenting as the greatest predictable sign of IDN exposure.

It is clinically relevant to identify the correlation between the occurrence of an IDN deficit and the presence of the radiographic signs. Our study showed a statistically significant difference in the risk of an IDN deficit in patients with lower third molars showing the specific radiographic sign of the root in close proximity to the IDC compared with those without any radiographic signs. We also found that darkening of the wisdom tooth root was the only significant radiographic sign on the OPGs of the 5 radiographic

FIGURE 6. Lower third molar showing several radiographic signs.

Leung and Cheung. Radiographic Signs, IDN Exposure, and Deficit. J Oral Maxillofac Surg 2011.

signs, with statistically significant difference in the incidence of an IDN deficit. This finding differed from the study by Rood and Shehab,[8] who found that the diversion of the IDC and the interruption of the IDC white line were significant signs. Nonetheless, general agreement has been reached in the published studies that radiographic darkening of the third molar root has the greatest correlation with the occurrence of an IDN deficit after third molar surgery.[8,17]

To our knowledge, the correlation between the number of radiographic signs and the occurrence of an IDN deficit has not been previously reported. In our study, we found that most of the patients with an IDN deficit had had 2 to 3 radiographic signs (Fig 6). None of the patients had 4 signs, which might require a larger sample size to show this possibility. By postulating from the incidence of IDN deficit among the number of radiographic signs, the risk of an IDN deficit increased by 10-fold when 2 or 3 radiographic signs were present versus when 1 radiographic sign was present in the impacted third molar to be removed.

The results of the present study will enable clinicians and patients to have a better estimation of the risk of lower lip paresthesia or anesthesia after lower third molar surgery by assessing the radiographic signs. However, this knowledge will not help to minimize the risk of an IDN deficit if the third molar must be totally removed. An alternative technique, such as coronectomy or intentional partial odontectomy, of third molars has been shown to reduce the risk of an IDN deficit when the third molar root is in close proximity to the IDN.[12,18,19] We believe our results will aid both clinicians and patients in the analysis of the risk of IDN damage and in decision making to choose between coronectomy and conventional total excision of the lower third molar. From the results of our study, we believe that any deeply impacted lower third molar showing darkening of the tooth root radiographically or with 2 or more of the 5 radiographic signs we have described will have a significant risk of a postoperative IDN deficit. The clinicians should offer the patients the option of undergoing coronectomy instead of total excision of a third molar.

The results of our study have shown that a lower third molar with the radiographic signs of its roots in close proximity to the IDC has a statistically greater risk of neurosensory deficit after total surgical removal than without radiographic signs. The prevalence of an IDN deficit was greater (20.8%) when the IDN was exposed compared with the prevalence in the group without IDN exposure (2.6%). The radiographic predictors of IDN exposure were confirmed to be darkening of the third molar root and displacement of the IDC by the third molar root. However, only the former sign was significantly associated with the presence of an IDN deficit, and the risk of a neurosensory deficit was much greater when 2 or more radiographic signs were present.

References

1. Bataineh AB: Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg 59:101, 2001
2. Carmichael FA, McGowan DA: Incidence of nerve damage following third molar removal: A West of Scotland Oral Surgery Research Group study. Br J Oral Maxillofac Surg 30:78, 1992
3. Gulicher D, Gerlach KL: Sensory impairment of the lingual and inferior alveolar nerves following removal of impacted mandibular third molars. Int J Oral Maxillofac Surg 30:306, 2001
4. Howe G, Poyton HG: Prevention of damage to the inferior dental nerve during the extraction of mandibular third molars. Br Dent J 109:355, 1960
5. Queral-Godoy E, Valmaseda-Castellon E, Berini-Aytes L, et al: Incidence and evolution of inferior alveolar nerve lesions following lower third molar extraction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 99:259, 2005
6. Valmaseda-Castellon E, Berini-Aytes L, Gay-Escoda C: Inferior alveolar nerve damage after lower third molar surgical extraction: A prospective study of 1117 surgical extractions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 92:377, 2001
7. Bell GW: Use of dental panoramic tomographs to predict the relation between mandibular third molar teeth and the inferior alveolar nerve: Radiological and surgical findings, and clinical outcome. Br J Oral Maxillofac Surg 42:21, 2004
8. Rood JP, Shehab BA: The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 28:20, 1990
9. Sedaghatfar M, August MA, Dodson TB: Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. J Oral Maxillofac Surg 63:3, 2005
10. Maegawa H, Sano K, Kitagawa Y, et al: Preoperative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 96:639, 2003
11. Miller CS, Nummikoski PV, Barnett DA, et al: Cross-sectional tomography: A diagnostic technique for determining the buccolingual relationship of impacted mandibular third molars and the inferior alveolar neurovascular bundle. Oral Surg Oral Med Oral Pathol 70:791, 1990

12. Leung YY, Cheung LK: Safety of coronectomy versus excision of wisdom teeth: A randomized controlled trial. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 108:821, 2009
13. Tay AB, Go WS: Effect of exposed inferior alveolar neurovascular bundle during surgical removal of impacted lower third molars. J Oral Maxillofac Surg 62:592, 2004
14. Cheung LK, Leung YY, Chow LK, et al: Incidence of neurosensory deficits and recovery after lower third molar surgery: A prospective clinical study of 4338 cases. Int J Oral Maxillofac Surg 39:320, 2010
15. Tantanapornkul W, Okouchi K, Fujiwara Y, et al: A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 103:253, 2007
16. Ohman A, Kull L, Andersson J, et al: Radiation doses in examination of lower third molars with computed tomography and conventional radiography. Dentomaxillofac Radiol 37:445, 2008
17. Blaeser BF, August MA, Donoff RB, et al: Panoramic radiographic risk factors for inferior alveolar nerve injury after third molar extraction. J Oral Maxillofac Surg 61:417, 2003
18. Pogrel MA, Lee JS, Muff DF: Coronectomy: A technique to protect the inferior alveolar nerve. J Oral Maxillofac Surg 62: 1447, 2004
19. Renton T, Hankins M, Sproate C, et al: A randomised controlled clinical trial to compare the incidence of injury to the inferior alveolar nerve as a result of coronectomy and removal of mandibular third molars. Br J Oral Maxillofac Surg 43:7, 2005