Reliability of panoramic radiography in evaluating the topographic relationship between the mandibular canal and impacted third molars

GIUSEPPE MONACO, D.M.D.; MARCO MONTEVECCHI, D.M.D.; GIULIO ALESSANDRI BONETTI, M.D., D.D.S.; MARIA ROSARIA ANTONELLA GATTO, M.D.; LUIGI CHECCHI, M.D., D.D.S.

The extraction of an impacted mandibular third molar can cause neurological complications that consist of temporary or permanent sensory alterations due to the damage in the inferior alveolar nerve.[1-3]

The presence of two or more radiographic markers, a high level of impaction and a horizontal tooth position are factors strongly linked to a contact between the third molar and the mandibular canal.

According to various surveys,[1-5] the rate of these neurological complications has varied from 0.5 to 1 percent for cases involving permanent damage and 5 to 7 percent for cases involving temporary damage.[1-5] The risk increases dramatically when there is contact between an impacted molar and the mandibular canal (defined as the absence of cortical bone around the alveolar nerve, the point at which the root touches the nerve). In these cases, the incidence of temporary damage to the inferior alveolar nerve rises to about 30 percent of extractions.[1,2,5,6]

Therefore, an accurate radiographic topographic diagnosis is necessary to estimate the risk involved with an anticipated extraction. In this way, panoramic radiography, or PR, permits an initial evaluation of any problems related to the impacted tooth. Nevertheless, there is a lack of accurate diagnostic criteria that the

ABSTRACT

Background. The authors conducted a study to evaluate the predictive value of five radiographic markers on the panoramic radiograph, or PR, to point out the relationship between the mandibular canal and the impacted third molar.

Methods. The authors evaluated the accuracy of the radiographic markers by comparing the PR with an axial computed tomographic, or CT, scan. They identified a sample of 73 third molars that showed a close relationship between the tooth roots and the mandibular canal on the PR, and then classified them on the basis of five radiographic markers. They also detected contact between the third molar and the mandibular canal on the CT scan.

Results. The distribution of the five radiographic markers was as follows: 37 teeth exhibited increased radiolucency, 13 exhibited superimposition, 14 exhibited interruption of the radiopaque border, 14 exhibited narrowing of the canal and seven exhibited diversion of the canal. In 11 cases, two or more markers were recognizable. The predictive values of a positive test result were as follows: increased radiolucency, 73 percent; superimposition, 38.5 percent; interruption of the radiopaque border, 71.4 percent; narrowing, 78.6 percent; and diversion, 100 percent. The authors detected contact in all of the cases that exhibited two or more markers.

Conclusion. Increased radiolucency, narrowing and interruption of the radiopaque border, as well as the concomitant presence of two or more radiographic markers, on the PR were highly predictive of contact between the third molar and the mandibular canal. An axial CT scan probably is indicated in such cases.

Clinical Implications. The results of this study may lead to some guidelines for oral surgeons evaluating whether to obtain an axial CT scan for further investigation after examining an impacted mandibular third molar via PR.

surgeon can use as a guide to deciding whether an axial computed tomographic, or CT, scan is needed in clinical situations in which PR is not sufficient to evaluate the risk of neurological complications.

The aim of this study was to assess the accuracy of five radiographic markers on the PR in predicting contact between the mandibular canal and the third molar.

SUBJECTS, MATERIALS AND METHODS

We selected 44 consecutive patients (a total of 73 teeth) from a sample of patients who visited the Department of Oral Surgery, University of Bologna, Italy, for extraction of impacted mandibular third molars during a two-year period. For all of these subjects, we observed an apparent contact between the third molar roots and the mandibular canal on the PR. The mean age of subjects was 26.6 years, with a range from 17 to 60 years.

The anatomical relationship between third molars and the mandibular canal has been classified according to five radiographic markers, easily recognizable on a PR and discussed in the literature.[7-9] They are as follows:

- superimposition of the tooth on the canal;
- increased radiolucency;
- interruption of the radiopaque border of the canal;
- diversion of the canal;
- narrowing of the canal (Figure 1[10]).

The authors tested the predictive value of the radiographic markers in diagnosing any contact between the third molar and the mandibular canal.

Description of radiographic markers. Superimposition occurs when the upper and lower cortical bone of the mandibular canal is superimposed on the root of the third molar (Figure 1A[10]). Increased radiolucency consists of a darker zone where the anatomy of both the root and the mandibular canal are less defined (Figure 1B[10]). Interruption of the radiopaque border of the canal by the third molar consists of interruption of the cortical bone, which constitutes the mandibular canal walls. On the radiograph, these lines appear radiopaque and constitute the roof and floor of the canal. The top line is interrupted most frequently (Figure 1C[10]).

Diversion of the canal is recognizable on the radiograph where the canal bends in proximity to the root or the crown of the third molar (Figure 1D[10]). Narrowing consists of a narrowing of the diameter of the canal resulting from close proximity to the third molar. This can be associated with deflection of the canal or deflection of the apex of the third molar roots (Figure 1E[10]).

We classified the teeth in this study according to criteria established by Pell and Gregory[11] (Figure 2,[10] page 315).

We tested the predictive value of the radiographic markers in diagnosing any contact between the third molar and the mandibular canal by comparing the PR with an axial CT scan (DentaScan software, GE Medical Systems–Europe, Buc, France). We also used the CT scan to test the correlation between grade and type of third-molar impaction and impingement on the canal, as well as to detect the canal position in relationship to the third molar.

Three of us (M.M., G.M., L.C.) evaluated the radiographs on a negative scope using a magnifying glass. To minimize intraobserver and interobserver variability, each surgeon made two evaluations; they then discussed their findings to reach a final evaluation. They evaluated the CT scans at least seven days after analyzing the PRs to avoid any memory effect.

In every case, the surgeon's first observation was in agreement with his second observation. With the exception of five cases, the surgeons agreed with each other in all PR evaluations. In these five cases, two operators classified the PR as exhibiting increased radiolucency and the third surgeon classified the PR as exhibiting superimposition. In these situations, we considered the opinions expressed by the two operators who were in agreement to be valid.

Statistical analysis. We used *t*-limits to calculate predictive values for positive test results (that is, the appearance of one or more radiographic markers) and the 95 percent confidence intervals, or CIs.[12] We used the χ^2 test in a monovariate analysis to examine the association between the presence of a contact point and the presence of each radiographic marker, as well as to choose the relevant variable to be used in a multivariate analysis. We used unconditional logistic regression to calculate the odds ratios, or ORs, and 95 percent CIs.[13]

RESULTS

Classification of teeth. We classified the 73 teeth according to the PR analysis as follows: 37

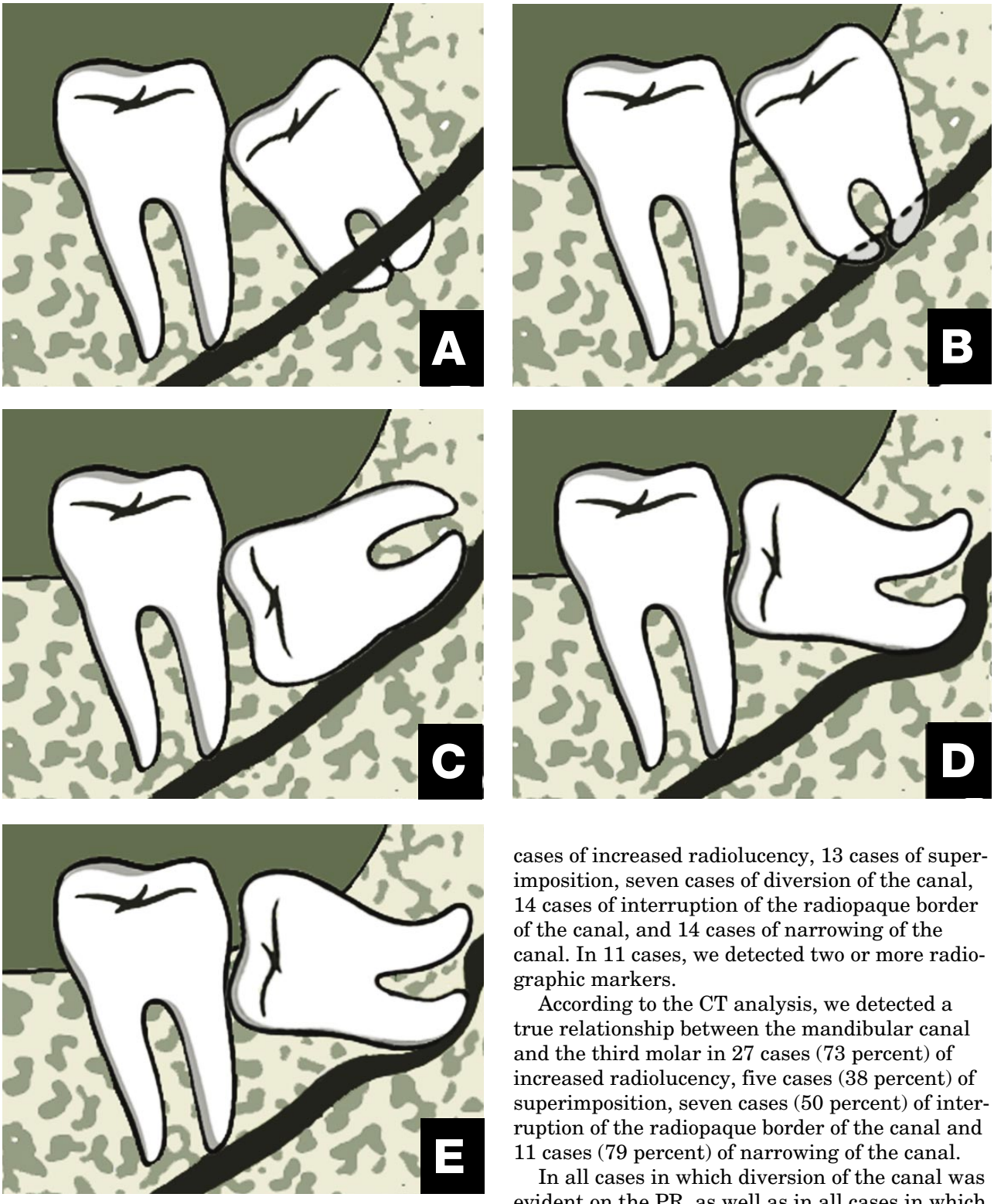

Figure 1. Five radiographic markers on the panoramic radiograph. A. Superimposition, B. Increased radiolucency. C. Interruption of the radiopaque border of the mandibular canal. D. Diversion of the mandibular canal. E. Narrowing of the mandibular canal. (Adapted with permission of the publisher from Checchi and Monaco.[10])

cases of increased radiolucency, 13 cases of superimposition, seven cases of diversion of the canal, 14 cases of interruption of the radiopaque border of the canal, and 14 cases of narrowing of the canal. In 11 cases, we detected two or more radiographic markers.

According to the CT analysis, we detected a true relationship between the mandibular canal and the third molar in 27 cases (73 percent) of increased radiolucency, five cases (38 percent) of superimposition, seven cases (50 percent) of interruption of the radiopaque border of the canal and 11 cases (79 percent) of narrowing of the canal.

In all cases in which diversion of the canal was evident on the PR, as well as in all cases in which two or more radiographic markers were evident, we observed a true relationship between the mandibular canal and the third molar on the CT scan.

We classified the third-molar impaction depth according to the criteria established by Pell and Gregory.[11] According to their classification system, the A, B and C positions reflect an increasing impaction depth. Of the 73 teeth examined in our study, 23 (31.5 percent) were in position A, 41 (56.2 percent) were in position B and nine (12.3 percent) were in position C.

According to the axial CT scan, a true relationship between the third molar and the mandibular canal was present in 10 teeth (43.5 percent) in position A, in 31 teeth (75.6 percent) in position B and in seven teeth (77.8 percent) in position C. We found a positive correlation between the depth of impaction as seen on the PR and the true relationship as determined by the CT scan; moreover, the frequency of contact between the molar tooth and the mandibular canal increased as the depth of impaction increased ($\chi^2 = 7.41$; $P = .02$) (Table).

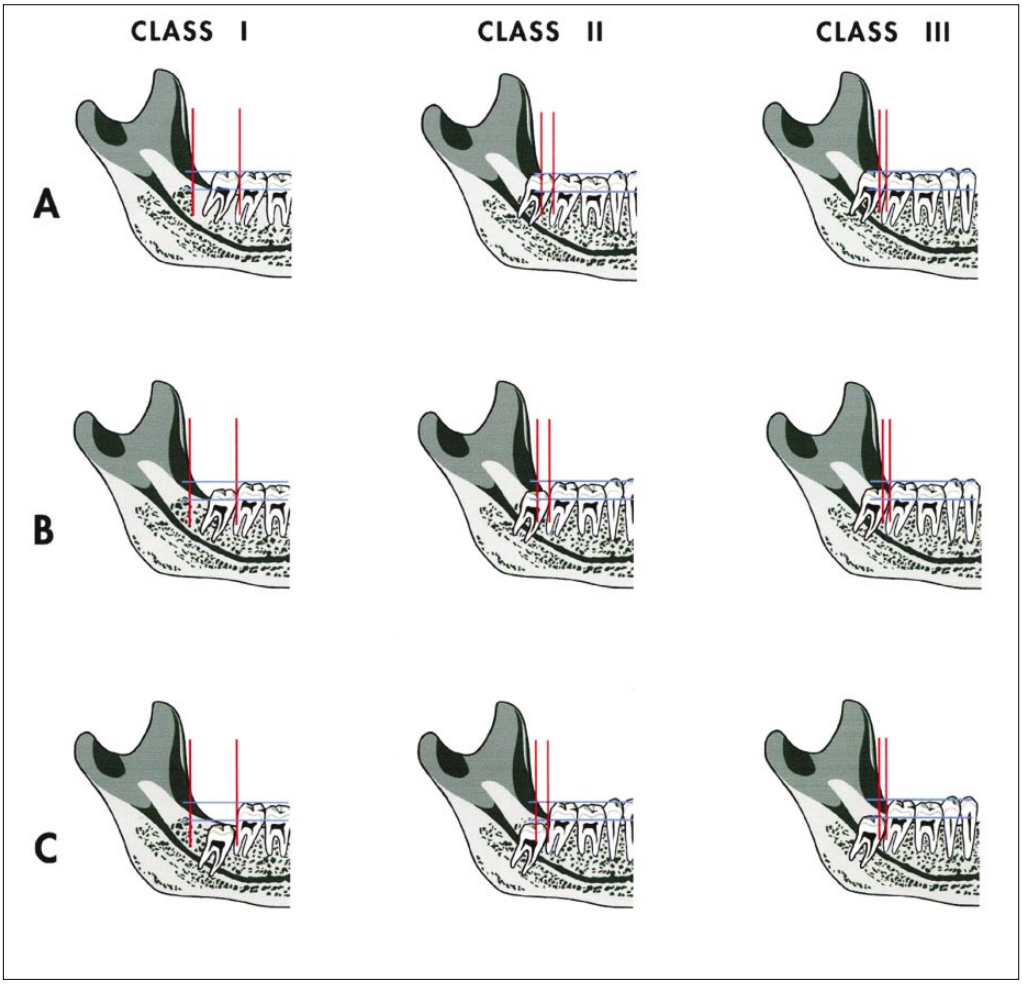

Figure 2. Third-molar impaction classified according to the critieria of Pell and Gregory.[11] (Reprinted with permission of the publisher from Checchi and Monaco.[10])

Pell and Gregory classification. We classified the third-molar crown position, in respect to the mandibular ramus, according to the system developed by Pell and Gregory.[11] In this system, Class I, II and III reflect an increasing amount of tooth covering by the mandibular ramus (Figure 2). In our sample of 73 teeth, 11 teeth (15 percent) were in Class I, 46 teeth (63 percent) were in Class II and 16 teeth (22 percent) were in Class III (the greatest amount of tooth covering). According to the axial CT scan, a true relationship between the third molar and the mandibular canal was present in six teeth (54.5 percent) in Class I, 27 teeth (58.7 percent) in Class II and 15 teeth (93.8 percent) in Class III. The frequency of contact between the molar tooth and the mandibular canal increased as the amount of covering increased ($\chi^2 = 7.20$; $P = .03$).

Of the 73 third molars examined, 18 (25 percent) were in a vertical position, 25 (34 percent) were mesioinclined, 28 (38 percent) were in a horizontal position and two (3 percent) were distally inclined. The axial CT scan showed a true relationship between the mandibular canal and the third molar in eight teeth (44 percent) in a vertical position, in 10 teeth (40 percent) that were mesioinclined, in three teeth (11 percent) in a horizontal position and in the two teeth (100 percent) that were distally inclined.

The axial CT scan also enabled us to evaluate

TABLE

PREDICTIVE VALUE OF RADIOGRAPHIC MARKERS ON A PANORAMIC RADIOGRAPH.

RADIOGRAPHIC MARKER	PREDICTIVE VALUE OF POSITIVE TEST RESULT (%)	CONFIDENCE INTERVAL (%)
Superimposition	38.5	10 to 66
Increased Radiolucency	73.0	59 to 87
Diversion of the Canal	100	91 to 100
Narrowing of the Canal	78.6	55 to 100
Interruption of the Radiopaque Border	71.4	45 to 97
More Than One Marker	100	93 to 100

the position of the mandibular canal in relationship to the third molar roots. In 14 cases, the canal was in a lingual position; in 37 cases, it was in an apical position; in 18 cases, it was in a buccal position; and in four cases, it was located between the roots.

In all of the teeth that exhibited interruption of the radiopaque border of the canal on the PR, the position of the mandibular canal was apical to the third-molar roots ($\chi^2 = 9.60$; $P = .02$). We found no statistical correlation between the course of the canal and the other radiographic markers.

According to the logistic regression analysis, the probability of a true relationship between the third molar and the mandibular canal was 4.1 times greater for the teeth in a horizontal position than for those in a vertical position (95 percent CI: 1.27 to 13.22), 6.7 times greater for teeth in a Class III position than for those in a Class I position (95 percent CI: 1.67 to 26.86) and 2.5 times greater for teeth in position B than for those in position A (95 percent CI: 1.29 to 4.84).

We also found that the absence of increased radiolucency reduced the risk of a true relationship between the tooth and the mandibular canal (OR: 0.27; 95 percent CI: 0.04 to 0.53).

DISCUSSION

An accurate radiographic diagnosis is essential to evaluate all of the possible problems related to a third-molar extraction. The PR, the periapical radiograph obtained via a parallel technique and the axial CT scan offer an increasing level of image definition and enable the oral surgeon to make a more accurate diagnosis.

The PR has an image distortion of about 20 percent compared with the patient's true anatomy, so it does not always provide the clinician with enough information for him or her to determine the actual risk level.[14]

Chandler and Laskin[15] demonstrated that experienced oral and maxillofacial surgeons cannot rely on PR alone to evaluate the actual level of third-molar impaction. They demonstrated that the degree of accuracy in classifying tooth impaction was no higher than 50 percent.[15]

By comparing a periapical radiograph of a third molar obtained via a parallel technique with another periapical radiograph obtained from a different projection, clinicians sometimes can clarify some of the diagnostic uncertainties that the PR cannot solve.[16] For those cases in which conventional radiographic techniques are not sufficient to evaluate accurately the risks of surgery, the oral surgeon can obtain an axial CT scan, which is extremely accurate and will enable him or her to better assess the anatomical relationship between the molars to be extracted and the mandibular canal. However, CT is an expensive procedure, and the radiation exposure is higher than it is for PR; therefore, CT should be used in only selected cases. For this reason, it is important to know the limits of a diagnosis made by using PR.

Among the five radiographic markers examined in our study, four have been evaluated in clinical studies performed on postextraction alveoli.[7,8] These studies demonstrated that a finding of increased radiolucency was accurate in predicting a close relationship between the mandibular canal and third-molar roots in 22 to 93 percent of cases; interruption of the radiopaque border of the canal was an accurate predictor in 26 to 80 percent of cases; narrowing of the canal was an accurate predictor in 17 to 59 percent of cases; and diversion of the canal was an accurate predictor in 17 to 74 percent of cases.[7,8] Superimposition has been evaluated in regard to postextraction paresthesia. This neurological complication occurred in only 2 percent of cases in which superimposition was identified on the PR.[7]

Sewerin and Andreasen[7] and Rood[17] reported

studies in which lower-lip paresthesia was present in 33 percent of cases of diversion of the canal, in 17 percent of cases of increased radiolucency and in 14 percent of cases of interruption of the radiopaque border of the canal. The percentages we found regarding the predictive value of superimposition, increased radiolucency and interruption of the radiopaque border are in agreement with those of the cited studies.[7,17]

However, the results of our study showed that narrowing of the mandibular canal had a predictive value of 78.6 percent, which is higher than the predictive values reported in the literature (17 to 59 percent).[7,8] We have found that this radiographic feature always is associated with other markers in cases in which a true relationship has been identified. In addition, we found a higher predictive value for diversion of the mandibular canal compared with the results reported by other studies (100 percent versus 17 to 74 percent).[7,8] Because of our small sample size, however (seven cases of diversion of the canal), these study results must be viewed with caution.

The results of this study show that horizontal inclination is the most dangerous position in terms of contact between the tooth and the mandibular canal.

In 11 cases in our study, we found more than one radiographic marker. In four cases, increased radiolucency was associated with narrowing of the canal. In two cases, narrowing of the canal and diversion of the canal occurred together. In four cases, interruption of the radiopaque border and narrowing of the canal occurred. In one case, we found diversion of the canal, increased radiolucency and narrowing of the canal.

For these 11 teeth, the CT scan confirmed a true relationship between the mandibular canal and the third molar. Consequently, it seems realistic to consider that the presence of two or more radiographic markers increases the probability of contact between the canal and the tooth. In such cases, CT enables the surgeon to confirm the diagnosis.

Many studies in the literature have pointed out the direct relationship between third-molar impaction depth and postextraction neurological damage.[1,18,19] The most likely reason could be the anatomical closeness between the third molar and the nerve vascular bundle, as well as the greater surgical complexity, which might lead to a higher probability of damage.

The results of this study show that deep tooth impaction along with a total "imprisonment" of the tooth in the mandibular ramus increase the frequency of contact between the third molar and the mandibular canal in a statistically significant way. In addition, the results of logistic regression confirm the importance of bony impaction of the third molar in regard to the relationship between the tooth and the mandibular canal. Moreover, these data are in alignment with reports in the literature.[1,18,19]

The results of our logistic regression show that the horizontal inclination of the third molar is the most dangerous position in terms of contact between the tooth and the mandibular canal. Similarly, previous studies of postextraction neurological damage, which evaluated inclination of the third molar toward the occlusal plane, pointed out a significant relationship between the horizontal position of the third molar and such damage.[1,19]

CONCLUSIONS

The results of this study may lead to some guidelines for oral surgeons who must decide whether an axial CT scan is needed in addition to preoperative PR for a patient who may undergo third-molar extraction. We believe that a CT scan probably is indicated in cases in which the predictive value of the radiographic marker or markers is high. In these cases, the oral surgeon needs to determine the precise anatomical relationship between the teeth and the mandibular canal. The CT scan enables him or her to do so.

Our evaluation of the five radiographic markers shows that periapical radiography is sufficient for cases in which superimposition is identified via PR (that is, axial CT is not necessary). Narrowing of the canal, increased radiolucency and interruption of the radiopaque border of the mandibular canal had a high predictive value in identifying a true relationship between the lower third-molar root and the mandibular canal. Under these circumstances, we believe a CT scan should be obtained to confirm the diagnosis. From a statistical point of view, increased radiolucency had the most accurate predictive value. The small number of cases classified as diversions of the canal preclude any conclusions.

The presence of two or more radiographic

Dr. Monaco is a visiting professor, Department of Oral and Maxillofacial Surgery, School of Dentistry, University of Bologna, Italy.

Dr. Montevecchi is a clinical fellow, Department of Periodontology, School of Dentistry, University of Bologna, Italy.

Dr. Alessandri Bonetti is a visiting professor, Department of Oral and Maxillofacial Surgery, School of Dentistry, University of Bologna, Italy.

Dr. Gatto is a researcher, Department of Oral and Maxillofacial Surgery, School of Dentistry, University of Bologna, Italy.

Dr. Checchi is a professor and chief, Department of Periodontology, School of Dentistry, University of Bologna, "Alma Mater Studiorum" Via S. Vitale 59, 40125, Bologna, Italy, e-mail "luigi.checchi@unibo.it". Address reprint requests to Dr. Checchi.

markers, a high level of impaction (according to Pell and Gregory's[11] criteria) and a horizontal position of the third molar are factors strongly linked to a contact between the third molar and the mandibular canal. Consequently, we recommend that an axial CT scan be obtained in such cases. ■

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