Risk Assessment Before Extraction for Immediate Implant Placement in the Posterior Mandible: A Computerized Tomographic Scan Study

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Background: Controversy exists in treatment planning relative to the attempt of saving a tooth with unfavorable prognosis or extracting it and placing an immediate or delayed implant. Preextraction radiographic assessments of teeth are traditionally performed using two-dimensional periapical and panoramic radiographs. These can reveal bone loss around a tooth, but have limited use in assessing implant risk before tooth extraction. Three-dimensional radiographs or cone-beam (CB) or computerized tomographic (CT) scans are often taken after tooth extraction and socket healing to assess the healed ridge as a potential implant site. However, when treatment planning for an immediate implant in the posterior mandible, a CT scan taken before tooth extraction can be of value in assessing the available bone and anatomy of the area. This allows the clinician and patient to consider alternative options, such as treating and maintaining the tooth or using a delayed implant protocol, when the site presents a high risk for immediate implant placement (IIP). The purpose of the present study is to assess the prevalence of sites associated with the mandibular second premolar, mandibular first molar, and mandibular second molar teeth that present high risk for IIP using a preextraction CT scan to assess the available apical bone and the anatomy of the posterior mandible in the area of the anticipated extraction site.

Methods: One hundred consecutive CT scans were obtained and screened from the New York University College of Dentistry, Office of Quality Assurance–Approved Implant Dentistry Database. Forty-one of these CT scans were further assessed because they included the presence of ≥2 of the following tooth types: mandibular second premolars, mandibular first molars, and mandibular second molars. Measurements were obtained on the axial sections of the selected teeth to evaluate the amount of bone available apical to the root apices to determine the frequency of sites where an IIP protocol presented a high risk for inferior alveolar nerve injury or lingual plate perforation.

Results: Of the 135 teeth assessed from 41 CT scans, 65% of the mandibular second premolars, 53% of the mandibular first molars, and 73% of mandibular second molars had <6 mm of bone available for IIP, presenting high risk for inferior alveolar nerve injury. Of the sites in which the inferior alveolar canal did not limit available bone for IIP, 7% of the second premolars, 9% of the first molars, and 31% of the second molars presented high risk for lingual plate perforation.

Conclusions: Preextraction CT scans may present a useful diagnostic aid to assess the risk of inferior alveolar nerve injury and lingual plate perforation for IIP in the posterior mandible. This information may be used for assessing risk when deciding whether to retain a questionable tooth or replace it with an implant with either an IIP or delayed protocol. *J Periodontol 2011;82:395-402.*

KEY WORDS

Anatomy; cone-beam computed tomography; dental implants; diagnosis; mandible; risk assessment.

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Implant-supported restorations placed with either an immediate or delayed protocol are a treatment option for the replacement of missing teeth.[1] High rates of survival have been reported for implants placed in healed bone of adequate horizontal and vertical dimension.[2] Implant lengths ≥10 mm and widths ≥4 mm remain the standard dimensions for the high implant survival rates reported in the literature.[3,4]

Immediate implant placement (IIP) into fresh extraction sockets has been documented to be a predictable treatment modality, with survival rates comparable to implants placed in healed ridges.[5-7] The advantages of this technique include single-stage surgery, reduction in treatment time, and earlier restoration and treatment completion, particularly in the posterior mandible, where esthetics are not a primary concern.[8] The IIP protocol has been shown in a recent systemic review of the literature to have high implant survival rates even in infected sites.[9]

However, the posterior mandible poses a unique challenge for successful IIP because of the location of the inferior alveolar canal (IAC) and the concavity of the submandibular fossa. These two anatomic factors may limit available bone, leading to potential complications. Injury to the inferior alveolar nerve can lead to partial or permanent paraesthesia.[10-13] Inadvertent instrumentation through the lingual cortical plate can lead to arterial trauma, which may result in the development of a sublingual or submandibular hematoma, excessive bleeding, or infection.[14]

Cone-beam (CB) or computer tomographic (CT) scans are usually taken after tooth extraction and before implant placement to assess bone quantity and morphology.[15,16] However, CB or CT scans taken before tooth extraction may be an important aid for treatment planning when considering IIP in the posterior mandible. To date, there are no available data assessing the risk of injury using preextraction three-dimensional scans when considering extraction of a questionable tooth and immediate placement of an implant.

The purpose of the present study is to determine the incidence of sites in the mandibular second premolar, mandibular first molar, and mandibular second molar areas that present high risk for IIP because of potential injury to the inferior alveolar nerve and perforation of the lingual plate.

MATERIALS AND METHODS

CT scans were obtained from the Ashman Department of Periodontology and Implant Dentistry at the New York University College of Dentistry (NYUCD) Kriser Dental Center. These data were extracted as de-identified information from the routine treatment of patients who presented to the department for periodontal and implant treatment. The information was certified by the Office of Quality Assurance at NYUCD. This study is in compliance with the Health Insurance Portability and Accountability Act requirements and approved by the University Committee on Activities Involving Human Subjects.

A total of 100 consecutive CT scans of the mandibular arch were evaluated. The inclusion criteria specified that each subject had to have ≥2 of the following teeth: either a mandibular second premolar or mandibular first or second molar, which did not necessarily have to be in the same quadrant. Forty-one CT scans satisfied this criteria and from these, 135 teeth were evaluated to identify the sites that posed a high risk for inferior alveolar nerve injury or lingual plate perforation for IIP. These 135 teeth were included in the statistical analysis by a randomized selection of one tooth type per subject, to ensure equal weighting of each subject. In subjects having >1 of the same tooth type (i.e., right and left second premolar teeth), these were both included. The presence of any periapical radiolucency was not considered in the measurements performed because all measurements were referenced from the level of the apices of the roots of the teeth and any apical pathology present did not extend to the IAC.

Four millimeters of implant anchorage in native bone was considered the minimum necessary to achieve primary stability to ensure immediate implant survival.[17,18] In this study, the amount of bone apical to the socket that is deemed necessary for IIP is 6 mm, which allows 4 mm for apical anchorage and a 2 mm safety zone.[19] The length of the implant was variable, depending on the height of the alveolar crest. However, the diameter was fixed at 4 mm, representing the minimum implant diameter required to support the occlusal load in the posterior mandible, while minimizing the risk of lingual plate perforation.[20-22]

To determine if an IIP protocol poses a high risk for inferior alveolar nerve injury, a measurement was taken on the axial sections of the mandibular second premolars, and mandibular first and second molars. A vertical line was traced with the use of computer software[†] from the level of the apices of the mandibular second premolars or the level of the apices of the mesial root of the mandibular first and second molars to the superior border of the IAC. This was designated as the root to alveolar canal (RAC) distance (Fig. 1). The available bone apical to the socket was defined as adequate for IIP when the RAC measured ≥6 mm (Fig. 2). When the RAC measured <6 mm, IIP was considered high risk for injury to the inferior alveolar nerve (Fig. 3). The probability of inferior alveolar nerve injury when placing an immediate implant was determined when the RAC measured
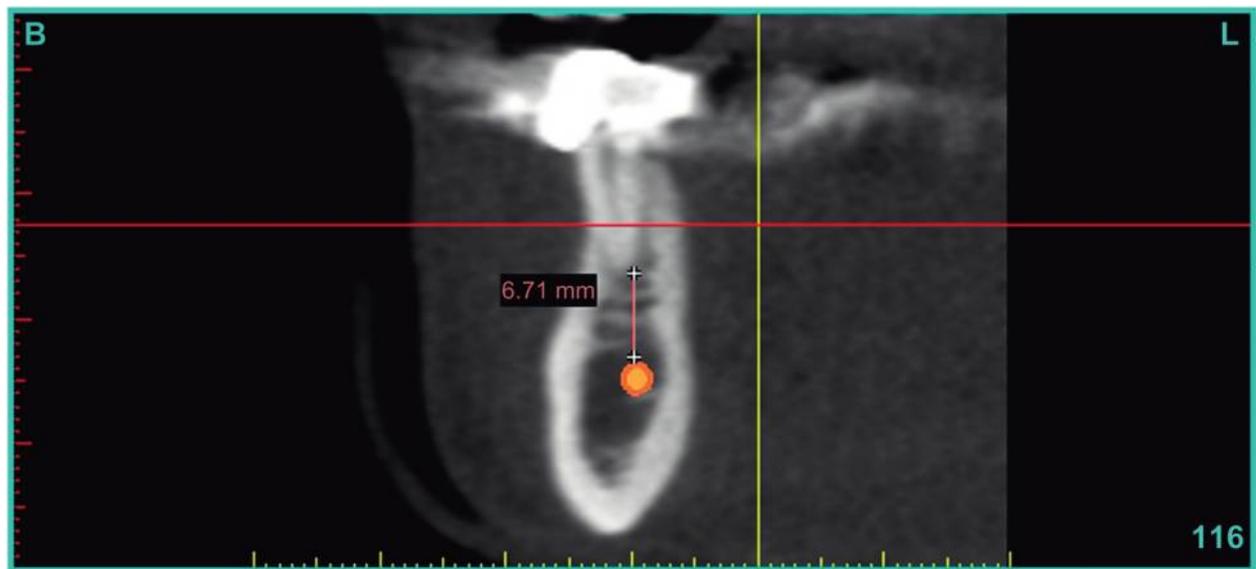
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† SimPlant, Materialise Dental, Leuven, Belgium.

Figure 1.
RAC measurement. Measurement of available bone measured apical to the root apices to the alveolar canal. Orange area signifies the tracing of inferior alveolar dental canal drawn with implant software.[‡]

<6 mm. The data set used for the analysis only allowed one tooth of each type per subject. The mean RAC for each tooth type was determined using a linear mixed-effects model with tooth type as the covariate and a random intercept for each subject. In each model the reference category (captured in the intercept) was the first molar. This model was necessary because the number of teeth analyzed in each subject varied, and ignoring this fact would have resulted in variable weighting for subjects.

In the scans evaluated, whenever the RAC distance was ≥6 mm, and IIP would not pose a risk for inferior alveolar nerve injury, the sites were further assessed to determine if the implant would present high risk for lingual plate perforation. To assess this risk, a simulated implant 4 mm in diameter was positioned vertically in ideal implant position according to the desired position of an anticipated replacement crown as indicated on the radiographic guide (Fig. 4). The proportion of sites with lingual plate perforation was determined, where again the data set only allowed one tooth of each type per subject.

The sex of each subject was also documented and statistical analysis was performed using a linear mixed-effects model and a frequency analysis to evaluate the collected data. A mixed-effects linear-model analysis was performed to determine differences between the sex of the subject and the RAC measurement.

RESULTS

Of the 135 teeth assessed from 41 CT scans, 65% of the mandibular second premolars, 53% of the mandibular first molars, and 73% of the mandibular sec-

ond molars had <6 mm of bone available for IIP and were thus considered a high risk for inferior alveolar nerve injury (Table 1). The mean RAC for each tooth type ranged from 4.41 mm for the second molar to 5.76 mm for the first molar (Table 2). There were statistically significant differences between the RAC for the first molar and second molar ($P = 0.001$) and between the first molar and the second premolar ($P = 0.008$). There were no statistically significant differences between the RAC for the second molar and the second premolar ($P = 0.594$).

Of the sites where the IAC did not limit available bone for IIP, 7% of the mandibular second premolars, 9% of the mandibular first molars, and 31% of the mandibular second molars presented high risk for lingual plate perforation (Table 3). Statistically significant differences between the RAC of males and females was noted for the mandibular first and second molars ($P = 0.003$ and $P = 0.004$, respectively), but not for the mandibular second premolars ($P = 0.052$).

DISCUSSION

IIP is an accepted and predictable surgical modality for the replacement of mandibular posterior teeth.[5] An immediate implant survival rate of 95% in the posterior mandible has been reported in the literature.[23,24] However, the anatomy of the posterior mandible, including the variability in the position of the IAC and the submandibular fossa, may pose a high risk for inferior alveolar nerve injury and lingual plate perforation when attempting to achieve primary implant stability using native bone apical to the extraction socket.[25]
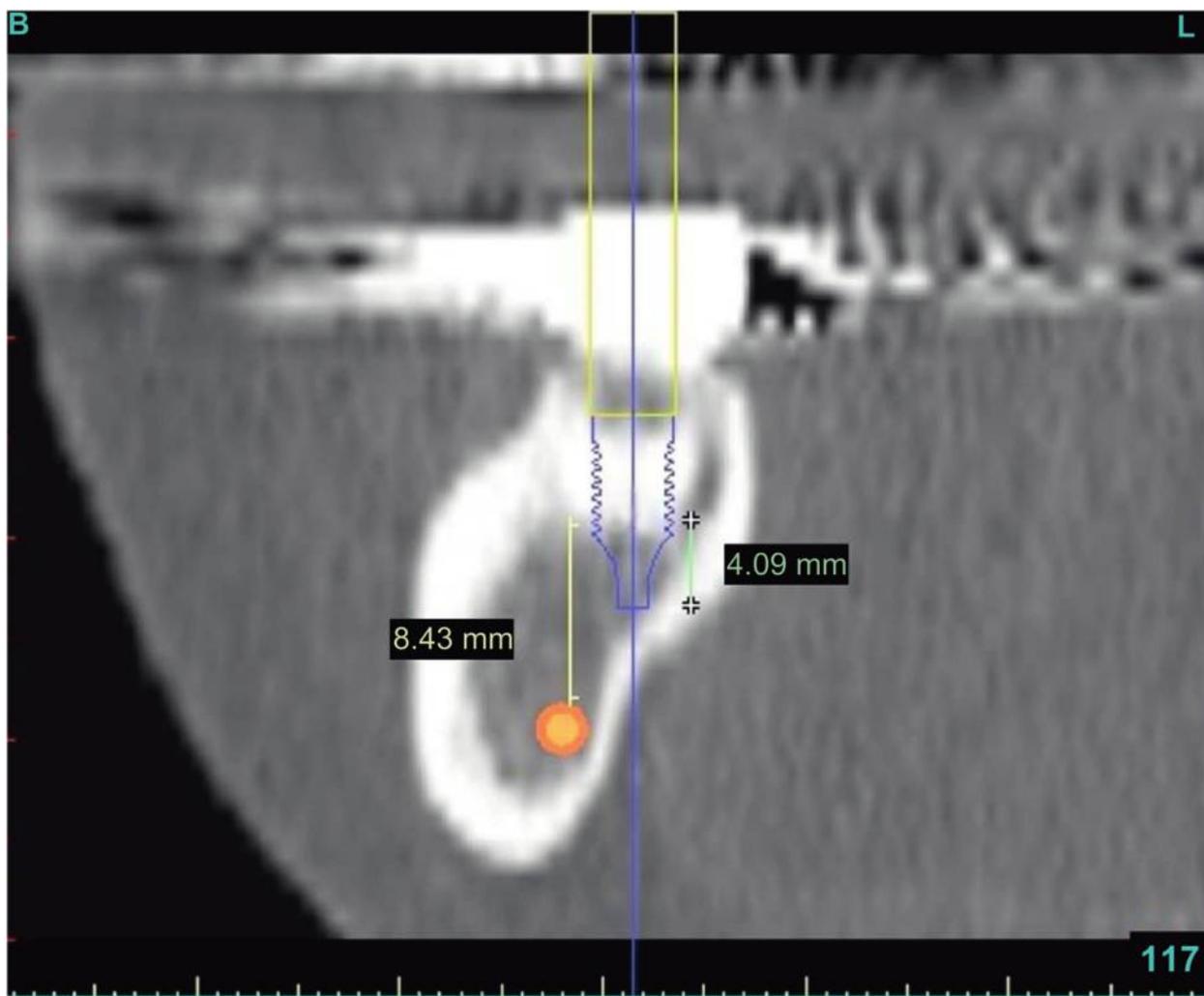
‡ SimPlant, Materialise Dental.

Figure 2.
RAC ≥6 mm. IIP does not present a high risk for inferior alveolar nerve injury. Orange area signifies the tracing of inferior alveolar dental canal drawn with implant software. Orange area signifies the tracing of inferior alveolar dental canal drawn with implant software.§

According to the results of this study, based on the statistical analysis of 135 teeth in 41 preextraction CT scans, 65% of mandibular second premolars, 53% of mandibular first molars, and 73% of mandibular second molars present high risk for inferior alveolar nerve injury when treatment planning IIP. If this risk is combined with the risk of lingual plate perforation, then the probability of a complication taking place for IIP of these teeth increases to 68% for the mandibular second premolars, 57% for the mandibular first molars, and 81% for the mandibular second molars. The incidence of inferior alveolar nerve paresthesia after implant surgery is underestimated in the dental literature because neurosensory changes can be transient and may go unreported.[25] A retrospective questionnaire of implant patients found that 36% of patients reported altered sensations, making inferior alveolar nerve paresthesia a growing concern as an implant complication and for medicolegal litigation in the dental profession.[26,27] The risk of inferior alveolar nerve injury as determined in this study seems to be higher than the incidence previously published. However, it should be noted that no study to date has calculated the risk of this complication using the IIP protocol with consideration to the anatomy of the posterior mandible and the limitations that this presents. Moreover, it is unknown how many implant procedures using the IIP in the posterior mandible were in fact aborted and how many cases of paraesthesia were not recorded in studies where the incidence of this complication was reported. To the authors' knowledge, this is the first study to date that uses preextraction CT scan information to determine this risk.

Four millimeters of bone height apical to the extraction socket is the measurement used on each CT scan
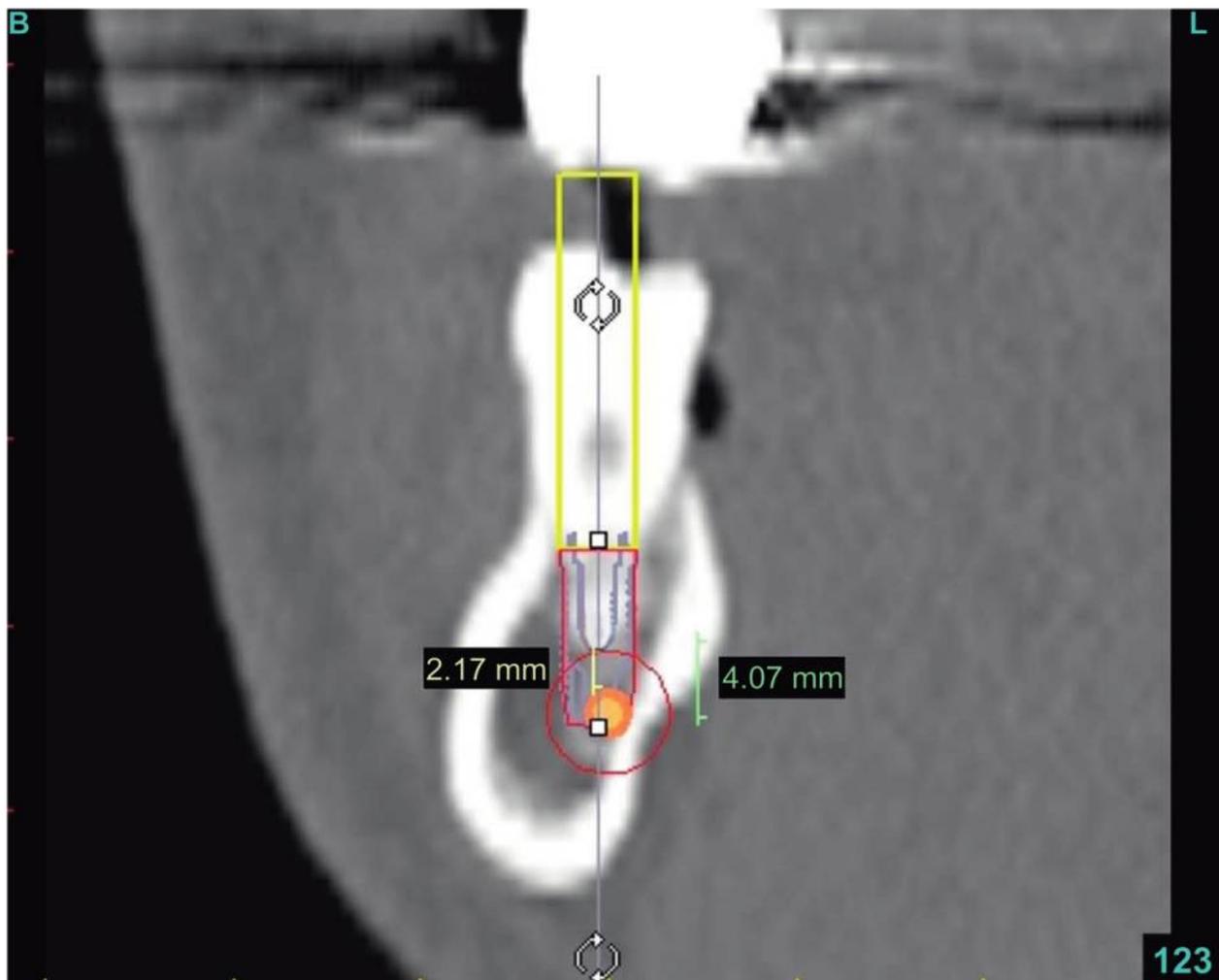
§ SimPlant, Materialise Dental.

Figure 3.
RAC <6 mm. IIP presents a high risk for inferior alveolar nerve injury. Orange area signifies the tracing of inferior alveolar dental canal drawn with implant software.[||]

in this study. This amount was assumed necessary for immediate implant anchorage.[28] Although some researchers suggest placement of implants in the interseptal bone to replace multirooted mandibular molars when using an IIP protocol, this bone being very cancellous and of poor bone quality is not considered ideal or stable because of the tendency toward resorption over time.[6] That is why only basal bone is considered in the present study. Basal bone is stable postextraction, easily identified on CT scans, and valuable in comparison between single and multirooted teeth and among subjects. The mean distance from the root apices of the mandibular second premolars and the distance from the mesial apex of the mandibular first and second molars to the superior border of the IAC in this study averaged 4.86, 5.76, and 4.41 mm, respectively. All of the mean values are less than the critical 6-mm safe distance assumed in this study. However, the standard deviation from the mean RAC

for each tooth type was 3 mm on average, which underscores the importance of individual risk assessment that can be determined by CT scan analysis. The mean RAC values are comparable to those reported in other studies based on measurements taken from dry skulls,[29] which highlights the accuracy of CT scans in providing reliable information for preextraction diagnosis.

Extrusion of the selected teeth is not recorded in this study because of lack of occlusal plane reference in some cases. Had extrusion taken place, however, the RAC distance would have been greater and thus decreased the risk of IAC violation as reported in this study.

Two-dimensional imaging has many limitations compared to three-dimensional imaging. Periapical radiographs do not identify the position of the mandibular canal in 28% of patients.[30] Distortion is reported to be 14% for periapical radiographs, 23% for panoramic
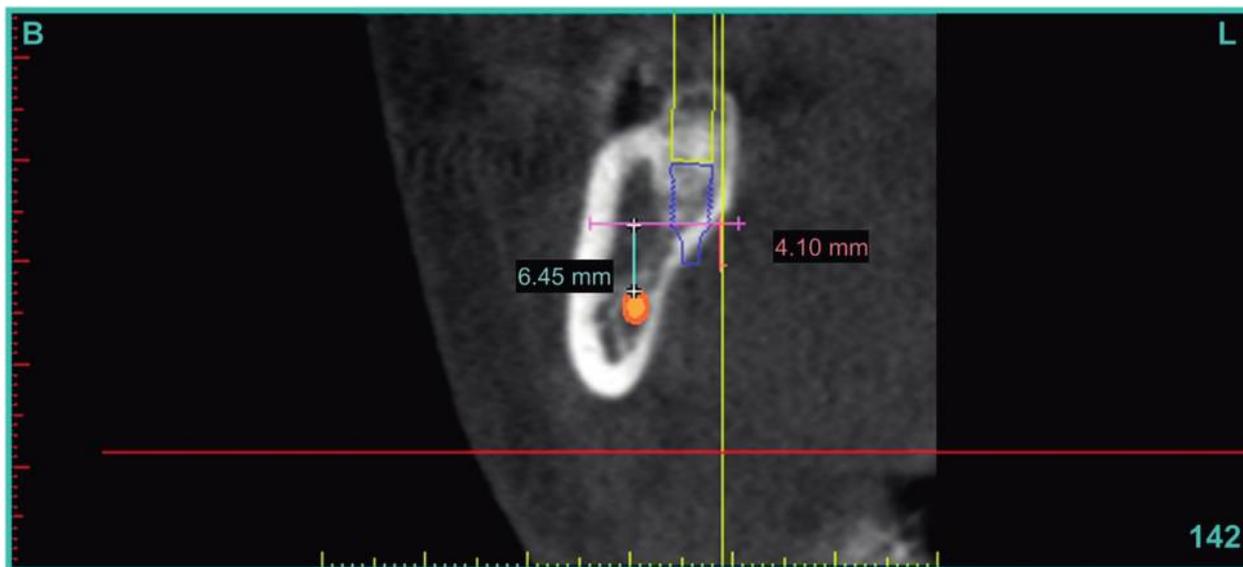
|| SimPlant, Materialise Dental.

Figure 4.
RAC ≥6 mm. IIP presents high risk for lingual plate perforation when implant is placed in ideal position to support the replacement crown. Orange area signifies the tracing of inferior alveolar dental canal drawn with implant software.¶

Table 1.

Probability of Inferior Alveolar Nerve Injury According to Tooth Type

Tooth Type	No. Teeth Analyzed	High Risk for Inferior Alveolar Nerve Injury	
PM2	40	26/40	65%
M1	47	25/47	53%
M2	48	35/48	73%

Table 2.

Mean RAC for Each Tooth Type

Tooth Type	Mean (mm)	SD (mm)
PM2	4.86	2.82
M1	5.76	3.07
M2	4.41	3.04

Table 3.

Probability of Lingual Plate Perforation According to Tooth Type

Tooth Type	No. Teeth Analyzed	High Risk for Lingual Plate Perforation	
PM2	14	1/14	7%
M1	22	2/22	9%
M2	13	4/13	31%

radiographs, and 1.8% for CT scans.[31] Therefore, CT scans provide a more accurate three-dimensional assessment.

In the present study, 7% of second mandibular premolars, 9% of first mandibular molars, and 31% of second mandibular molars present high risk of lingual plate perforation when placing an immediate implant 4 mm in diameter. However, if a larger-diameter implant was selected, the probability for lingual plate perforation would increase, and if undiagnosed at the time of implant placement could present life-threatening complications.[32]

Currently in clinical practice, considering the high rates of implant survival, many posterior mandibular teeth requiring multidisciplinary treatment may be extracted and replaced by implant-supported restorations.[33,34] However, controversy remains as to when retaining a tooth may be considered hopeless and when replacing it with an implant may be considered overtreatment.[35] Longitudinal studies show high survival for questionable mandibular molars after active periodontal therapy and regular professional maintenance.[36-39] Furthermore, clinical furcation closure using periodontal regenerative procedures in the treatment of Class II furcation defects in mandibular molars

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has been shown to result in predictable treatment outcomes, with reported success rates varying from 72% to 90%.[40-43] Wagenberg and Froum[6] reported that implants placed after tooth extraction because of periodontal disease were 2.3 times more likely to experience failure than implants placed after tooth extraction unrelated to periodontal disease. When the preextraction CT scan indicates high risk, the clinician should first consider periodontal treatment and retaining these teeth, and if they are not amenable to periodontal therapy, then allowing a healing period after extraction to assess the site for delayed implant placement.

Preextraction CT scans are not routinely performed in evaluating a potential implant site because remodeling of the alveolar bone changes the dimensions of the alveolar ridge.[44] This then may necessitate taking an additional scan postextraction if a decision is made to remove the involved tooth and use a delayed implant protocol. However, with the use of CB scans radiation exposure is 20% that of a conventional CT scan and equivalent to a full-mouth series of radiographs.[45]

According to the present study, IIP in the posterior mandible may pose a high risk for inferior alveolar nerve injury and lingual plate perforation in a significant number of patients. Alternative treatment options include the use of shorter and wider implants. However, to date there are limited long-term data available with these types of implants.[46] Immediate implants can also be placed at an angle to avoid anatomic structures, although this may pose restorative problems. The decision to treat and retain a periodontally involved tooth could be more accurately weighed in light of the implant risks revealed with the information obtained from a preextraction CT scan as described in the current study.

Because this study only assesses the risk associated with IIP, further research is required after extraction to assess how many of these sites may still present high risk for delayed implant placement.

CONCLUSIONS

Preextraction CT scans of periodontally involved, questionable teeth present a valuable diagnostic aid to assess risk for IIP in the posterior mandible. Based on the results of this study, placing an immediate implant may present a high risk for inferior alveolar nerve injury in 53% to 73% of first and second mandibular molar sites and second mandibular premolar sites; considering the sites where the inferior alveolar nerve was not a limitation, 9% to 31% of these sites presented a high risk for lingual plate perforation. These complications present debilitating and even life-threatening situations for the patient.

Based on the high risk levels for the previously mentioned teeth reported in this study, other treatment options designed to save the involved tooth or extraction with the use of a delayed implant protocol should be considered. Based on the results of this study, it is advisable to take a CT scan before extraction to evaluate all treatment options available, and to be able to anticipate and avoid potential complications while fully informing the patient of the risks of each option.

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