Three-Dimensional Alveolar Bone Assessment of Mandibular First Molars with Implications for Immediate Implant Placement

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The aim of this retrospective study was to evaluate the alveolar dimensions of the mandibular molar using cone beam computed tomography (CBCT) for immediate implant placement. The width of buccal (WB) and lingual (WL) bone; width of interradicular bone 2 and 4 mm apical to the furcation and at the apex (IRB2, IRB4, and IRBA, respectively); and distance to the inferior alveolar nerve from the furcation (IAN-F) and mesial (IAN-M) and distal (IAN-D) roots were evaluated from CBCT records of 126 subjects (200 mandibular first molars). Mean WB (0.84 ± 0.39 mm) and WL (2.71 ± 1.17 mm) measurements showed significant differences (P = .003). Differences between IAN-F, IAN-M, and IAN-D measurements averaged at 14.14 ± 2.57 mm, 4.31 ± 1.06 mm, and 4.61 ± 1.02 mm, respectively. IRB2, IRB4, and IRBA dimensions were 1.93 ± 0.65 mm, 2.54 ± 0.9 mm, and 4.46 ± 1.91 mm, respectively. The findings of the study demonstrate the alveolar bone morphology of the mandibular first molar and the need for CBCT scans for proper treatment planning for immediate implant placement. Int J Periodontics Restorative Dent 2020;40:e163–e167. doi: 10.11607/prd.4614

Introduced almost 35 years ago, dental implants have revolutionized the field of oral rehabilitation. With a success rate of over 90% over 10 years, endosseous implants can now be successfully and predictably used to replace missing teeth in the oral cavity. The major clinical advantage of a dental implant over a fixed partial denture is that they do not require tissue destruction of healthy adjacent teeth.

Traditional practice dictated a healing period after tooth extraction and a second surgical procedure thereafter to place the implants. Following this, a third surgical appointment was required to expose the implants for restoration. Although this protocol was technically less demanding, it subjected the patients to multiple surgical interventions. With the advent of the immediate implant placement protocol, an implant could be placed at the time of tooth extraction when possible (depending on the mandibular root anatomy), and concomitant regenerative therapy could be performed if necessary. This would thus reduce the number of surgical procedures and the overall treatment time.

According to the past literature, the most frequently extracted teeth have been molars. A study by Matsuda et al in 2016 evaluated the alveolar bone anatomy of

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the maxillary first molars. However, not much has been published regarding mandibular molar alveolar bone anatomy for immediate implant placement. Since immediate implants in the mandibular molar region engage the interradicular bone, its detailed anatomy, along with variances, is essential for such procedures. Anatomically limiting structures, such as the inferior alveolar nerve, combined with poor quality or inadequate interradicular bone may impede attainment of implant primary stability during immediate-placement procedures. The aim of this study was to evaluate the alveolar dimensions of the mandibular molar using cone beam computed tomography (CBCT) for immediate implant placement. To the authors’ knowledge, this is the first study assessing the mandibular molar alveolar bone anatomy from the point of view of an immediate implant placement.

**Materials and Methods**

The materials for this retrospective study included dental CBCT images taken using the same scanning machine (Galileos, Dentsply Sirona) with standardized patient-positioning and exposure factors (0.4-mm voxel, 120 kVp, 3 to 8 mA), as advised by the manufacturer. The selected radiographs were from subjects without radiographic or clinical evidence of periodontal disease, severe root resorption, trauma, or periapical lesions. Radiographs with at least one mandibular first molar and at least two occluding posterior teeth in the same quadrant were included. Subjects who had undergone surgical treatment or tissue regenerative procedures in the mandibular posterior region were excluded from the study.

The CBCT images were presented on the same computer with screen size 1680 × 1050 pixels (384 MB, Intel HD Graphics 3000) with the same software used for all the CBCT scans (Galaxis, Dentsply Sirona). In all cases, digital images were analyzed using the full facilities of the Galileos viewer software. All images were presented in full volume size and with the option to change all possible setting options (adjusting of contrast, scrolling through volume). All measurements were performed by a single examiner (N.P.) and were later verified by a second examiner (N.B.). The intraexaminer calibration was determined using kappa statistics, which showed a high level of agreement (κ > 0.80). The following measurements were obtained for the mandibular first molar (Figs 1 and 2): (1) The width of buccal (WB) and lingual (WL) bone 2 mm apical from the crest; (2) the distance from the inferior alveolar nerve to the furcation (IAN-F); (3) the distance from the inferior alveolar nerve to the apex of the mesial (IAN-M) and distal (IAN-D) root; (4) the mesiodistal...
(MD) and buccolingual (BL) socket size at the crest level; and (5) the width of the interradicular bone (IRB2) and 4 mm (IRB4) apical to the furcation and at the root apex (IRBA) between the mesial and distal roots.

All recorded data were entered in Microsoft Excel (version 2010) and tabulated. Data analysis was done using MedCalc Statistical Software version 13.3.1 for Windows. Descriptive statistical analysis of all data was done, presented as mean ± standard deviation (SD) with significance set at .05. Wilcoxon signed rank test was used to detect significant differences in data sets.

Results

The CBCT images of 200 permanent mandibular first molars from 126 patients (83 men, 43 women; mean age: 44.2 years) were evaluated. The MD and BL socket sizes at the crest were 8.77 ± 0.87 mm and 7.76 ± 0.75 mm, respectively. A significant difference (P = .003) was seen between the mean dimensions of the WB (0.84 ± 0.39 mm) and WL (2.71 ± 1.17 mm). Mean IRB2, IRB4, and IRBA measurements were 1.93 ± 0.65 mm, 2.54 ± 0.9 mm, and 4.46 ± 1.91 mm, respectively. IRBA < 3 mm was seen at 38% of sites. The mean IAN-F distance was 14.14 ± 2.57 mm (Fig 3), while the mean IAN-M and IAN-D measurements were 4.31 ± 1.06 mm and 4.61 ± 1.02 mm, respectively, showing no statistically significant difference (P = .15). In 24% of the study population, the IAN-F was < 10 mm.

Discussion

The present study investigated the dimensions of the alveolar bone around permanent mandibular molars using CBCT images. Among the mandibular molars, first molars have the least root anatomical variance14 and hence were chosen as representative samples for this study. The findings of this study have implications for extraction and immediate implant placement for mandibular first molars. Inadequate and poor bone quantity influences the insertion torque value during immediate implant placement, thus compromising primary stability and osseointegration.15

A plethora of evidence points toward the reliability and accuracy of CBCT as a tool to assess the dimensions of the bone,16,17 and to the authors’ knowledge, this was the first study three-dimensionally evaluating the anatomy of the alveolar bone around a mandibular first molar for immediate implant placement.

Distances to the alveolar nerve from root apices and furcations of the mandibular first molars were measured. These measurements determine the dimensions of the residual alveolar bone available for immediate implantation after tooth extraction. Although sufficient height from the furcation to the alveolar nerve was available to place a standard-dimension implant (4-mm diameter) in 76% of the evaluated sites, a lack in the width of interradicular bone was noted. The mean interradicular bone width for all samples across all evaluated sites (2 and 4 mm apical to the furcation and at the apex of the teeth) was 3.04 mm. Since the immediate implants engage the interradicular bone in the mandibular molars,18 primary
stability would be greatly compromised in sites with an interradicular bone width less than 3 mm (38% of samples). Such sites would demand from the clinician a high level of technical and operatory skills. Additionally, hard tissue augmentation may also be needed as an adjunct to implant placement in these patients.\textsuperscript{19} In the molar site, along with the implant and platform diameters, the implant height also plays a crucial role in its survival.\textsuperscript{20} For a single unsplinted implant, a minimum height of 10 mm is preferred to attain osseous anchorage as support for occlusal forces.\textsuperscript{21} However, 24% of sites had IAN-F dimensions < 10 mm and would either require a staged vertical bone augmentation procedure or rehabilitation using shorter implants. However, these short implants (< 10 mm height) usually need to be used in combination with additional implants that allow splinting of the implant-supported prosthesis.\textsuperscript{22–24} The residual bone dimensions of ≤ 2 mm, as determined by the IAN-M and IAN-D values, were found in 12% of the study population. These poor residual bone dimensions may negatively influence the implant primary stability and could thus be considered contraindications for immediate implant placement.\textsuperscript{19}

Cortical bone thickness has been shown to influence bone fill in extraction sockets.\textsuperscript{12} Also, thicker cortical plates are less likely to fracture during tooth extraction or resorb after the extraction. The mean buccal and lingual cortical plate dimensions among the subjects of the present study were 0.91 mm and 2.92 mm, respectively, and 63% of the samples had buccal plate dimensions < 0.5 mm. In such cases, preservation of the cortical plate during extraction would be extremely challenging, if not impossible. Findings from a previous study\textsuperscript{12} indicate that a cortical plate thickness ≥ 1 mm had better outcomes after immediate implant placement than sites with thin cortical plates (< 1 mm). Increased cortical bone thickness may offer a favorable prognosis for healing of the gap in immediate implants.\textsuperscript{25}

This study has its share of limitations, which need to be taken into account when extrapolating results. One limitation was the absence of data on the systemic health of the included subjects. The trauma to the alveolus associated with extraction prior to immediate implant placement cannot be judged. Also, a larger sample size would have been a better representation of the population.

Conclusions

This study highlights the importance of CBCT use for immediate implant planning in the mandibular molar region. Accurate diagnosis with careful case selection will allow clinicians to recognize sites indicated for immediate implant placement and those requiring a staged approach.

Acknowledgments

The authors declare no conflicts of interest.

References

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