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Risk assessment of inferior alveolar nerve injury for immediate implant placement in the posterior mandible: A virtual implant placement study

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ABSTRACT

Objectives: To investigate the prevalence and morphological parameters of lingual concavity, and whether these factors are related to a higher risk of inferior alveolar nerve (IAN) injury when performing an immediate implant surgery in posterior mandible region.
Methods: The CBCT images from 237 subjects (1008 teeth) were analysed the shape of the mandibles (C, P, U type), dimensional parameters of lingual concavity (angle, height, depth), and its relation to inferior alveolar canal (IAC) (A, B, C zone), RAC (distance from root apex to IAC) and probability of IAN injury. Multiple logistic regression modelling to determine the odds ratio of variables that made an important contribution to the probability of IAN injury and to adjust for confounding variables.
Results: The U type ridge (46.7%) and the most concave point located at C zone (48.8%) are most prevalent in this region. The mandibular second molar presents highest risk for IAN injury than other tooth type ($p < 0.001$), which were 3.82 times to occur IAN injury than the mandibular second premolar. The concave point located at A zone and B zone were 7.82 and 3.52 times than C zone to have IAN damage, respectively. The probability of IAN injury will reduce 26% for every 1 mm increase in RAC ($p < 0.001$).
Conclusions: The tooth type, morphological features of lingual concavities, and RAC are associated with risks of IAN injury during immediate implant placement.
Clinical significance: Pre-surgical mapping of the IAC and identification of its proximity relative to the lingual concavity in the posterior mandible regions may avoid unpleasant complications, specifically when performing immediate implant procedures.

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1. Introduction

While implant therapy has evolved into an integral part of daily dental practice, the attention is now directed towards simplification of the minimal invasive surgical procedure, and achieving pleasant aesthetic outcomes.[1,2] Regarding timing of implant placement, although delayed placement is more commonly practiced than immediate placement, placing implants directly in extraction sockets offers considerable advantages over conventional implant treatment.[3–8]

Immediate implant placement into fresh extraction sockets has attracted attention since the first publication on this topic over 30 years ago.[9] Despite clinical evidence that immediate implant placement leads to high implant survival rates,[6,7,10] this procedure is primarily recommended in sites with low aesthetic demand and favourable anatomy such as the premolar area.[5] As a result of patients' reservations and increasing of their acceptance towards implant therapy, placing immediate implants have given promising results on the benefits of immediate implants over delayed implant placement.[1,6–8] The obvious social and economic advantages include shorter treatment time along with reduced surgical intervention; extraction sockets allow for ideal positioning of implants,[4,6,10] conservation of bony structures,[8] preservation of soft tissue[2,6,11] meaning prosthetic treatment are simplified ensuring higher patient comfort and satisfaction.[6,7,11]

Although several evidence-based studies have presented clear clinical guidelines for implant procedures regarding patient selection and/or for optimal outcomes,[5,10] certain risks and complications are inevitable.[4,7,12–15] It has been shown that immediate implant placement beyond the alveolar housing may result in perforation of the lingual cortex,[3,14,16] damaging vital anatomical structures such as neurovascular injuries,[12,15] especially in the posterior mandible region, which may result in inflammation, infection ultimate loss of implants, and even life threatening events.[3,4,14,16–20] Accordingly, immediate implant placement should only be used in stringently evaluated situations and only be performed by experienced clinicians to reduce the chance of implant failure.[6,7]

Recently, cross-sectional information, such as conventional tomography, computed tomography systems, and magnetic resonance imaging,[21–23] has been recognized as part of diagnosis and treatment planning as it provides vital information ensuring optimal placement and alignment of immediate implants during and after the procedure.[3,4,14,16,19] Although the information concerning immediate implant placement and the significance of the lingual concavity in posterior mandible regions, more specifically the location and dimensional parameters of the lingual concavity, is related to the potential risk of inferior alveolar nerve (IAN) injury, there is still only limited amount of knowledge on this topic.

Therefore, the aims of this computer simulation study are to investigate the prevalence, and dimensional parameters of lingual concavities, and to determine whether the presence of lingual concavity is related to a higher risk of IAN injury when performing an immediate implant surgery in the posterior mandible region.

2. Materials and methods

2.1. Image acquisition and patient confidentiality

All the participants in this study are patients requiring dental implant treatment in the Department of Dentistry, Tri-Service General Hospital, Taipei, Taiwan. Basic information regarding the subjects' age, gender, and history of past treatment was recorded. All images were taken using a cone-beam computed tomography (CBCT) machine (NewTom 5G; QR, Verona, Italy) by board-certified radiologists from Nov 2009 to Jul 2013, and were not specifically acquired for this project. The CBCT scans were saved in the Digital Imaging and Communications in Medicine (DICOM) format with codes for corresponding names thus, the data was saved in an encrypted file confidentially protected yet retrievable if needed. The project and protocol were approved by the Institutional Review Board of Tri-Service General Hospital (TSGHIRB No. 2-102-05-064).

2.2. Inclusion and exclusion criteria

Images selected for this study had to fulfil the following inclusion criteria:

- one of permanent mandibular second premolar, permanent mandibular first molar, or permanent mandibular second molar had to be fully erupted;
- each tooth had to have fully formed apexes;
- the outline of the mandible, inferior alveolar canal (IAC) had to be easily identified;
- each tooth had to be normally positioned (the imaginary line connecting the cusp tip of canines, central grooves of premolars, and molars was generally smooth);
- opposing maxillary tooth were present to provide information for implant angulation;

Images were excluded if:

- images were unclear or incomplete due to scattering or other reasons;
- images had a missing tooth, an implant, or grafted alveolar ridge;

All images displayed on a 19-inch LCD monitor were reoriented and inspected by two examiners (Dr. M.-H. Lin, and Dr. L.-P. Mau). An intra-examiner calibration based on the anatomic diagnosis of CBCT images was performed to assess data reliability. After intra-examiner calibration, the two examiners separately evaluated the images, and any disagreement in the interpretation of images was discussed until a consensus was reached.

2.3. Assessment of the cross-sectional morphology

The qualified CBCT images were analysed by commercially available three-dimensional (3D) navigation software (ImplantMax® 4.0; Saturn Image, Taipei, Taiwan). If the tooth was present and met the inclusion criteria, a cross-sectional image of the region of interest (ROI), the centre section of

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