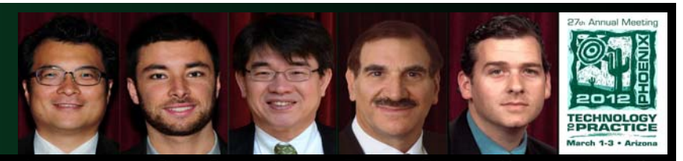
The Use of Computerized Tomographic Scans to Guide Implant Placement Lateral to the Inferior Alveolar Canal



Kang, Hyung Wuk; Zangrandi, Diego; Hong, Wei-Tse; Gutierrez, Lourdes; Yoon, Yeo-Eun; Kye, Wayne; Cho, Sang-Choon; Froum, Stuart; Bloom, Mitchell.

Ashman Department of Periodontology and Implant Dentistry
New York University College of Dentistry

INTRODUCTION

Bone atrophy of the posterior mandible following loss of dentition can represent a challenge for implant placement (Fig 1). Many patients reject the use of removable prostheses, viewing them as a handicap not only to oral function but effecting the quality of life. As a consequence, restoration of oral function through placement and restoration of implants is often welcome. In fact the two implants overdenture is now accepted as the standard of care for fully edentulous mandibles (1).

Long-term studies have demonstrated that partially or completely edentulous jaws can be restored successfully with implant-supported fixed prostheses (2-7). However, resorption of the alveolar ridge often leaves minimal bone superior to the inferior alveolar nerve (IAN), precluding placement of implants of favorable length (8). Although acceptable success rates have been achieved with implants less than 10 mm long, even the placement of short implants may represents an increased risk (9, 10)(Fig 2).

Over the years, various strategies have been proposed to overcome the anatomic and physiologic limitations of implant placement in the posterior mandible. Surgical interventions including guided bone regeneration, distraction osteogenesis and nerve transposition have been utilized (11-14). While these methods have obtained a level of success, the evidence relating to the predictability of surgically increasing vertical ridge height is limited (15). At the same time, a prosthetic solution may not be applicable because of inadequate interarch space. Reports on the use of a short and wide diameter implant have shown conflicting results (16-24). The IAN transposition technique allows for the engagement of more bone to support implants (25). However, there are a number of possible complications associated with these procedures that must be considered during treatment planning. The most common complication is prolonged neurosensory disturbance due to damage to the neurovascular bundle (26-28). In rare situations, iatrogenic or pathologic fracture of the mandible may occur (28).

An alternate approach is to place the implant lateral to the IAN. This approach could help minimize nerve injury when placing implants in the severely atrophied posterior mandible. Presurgical and pre-extraction computerized axial tomographic (CAT) scans have been used to analyze feasibility of immediate implant placement in the mandibular premolar and molar area relative to the position of IAN and lingual convexity (29). Cone-beam computerized tomographic (CBCT) scans are usually taken to assess bone quantity and morphology of atrophic posterior mandible. The feasibility of this technique depends on the volume of bone available buccally to the IAN in the mandible molar area. Due to the current wide accessibility of the CBCT scans, the safety zone can be readily verified even during the surgical procedure. The assessment of existing bone between IAN and the buccal cortical plate is critical when placing implants lateral to IAN (Fig 3). However, there is limited information in the literature regarding the available bone lateral to IAN to place implants (30).

The purpose of the present study was to determine the amount of bone available for implant placement lateral to the inferior alveolar canal relative to the location of the mandibular canal by using CBCT analysis in the areas of the mandibular first and second molar.

MATERIALS & METHODS

Clinical data in this study was obtained from Implant Database (ID). This data set was extracted as de-identified information from the routine treatment of patients at the Ashman Department of Periodontology and Implant Dentistry at New York University College of Dentistry. The ID was certified by the Office of Quality Assurance at NYUCD. This study is in compliance with the Health Insurance Portability and Accountability Act (HIPAA) requirements.

Study Subjects

This retrospective study utilized 40 consecutive CBCT scan images of 40 subjects from an available 2000 CAT-scan of patients who were candidates for implant treatment at New York University Ashman Department of Implant Dentistry. CAT-scan images from a pool containing well discernable images of the mandibular canal were selected randomly and given serial numbers and thereafter recognized by that serial number only. All chosen images were missing all of the posterior teeth unilaterally or bilaterally. The gender and exact age of the individual patient could not be determined because the ID did not link these parameters to the CAT scans. The distance between mandibular canal and the buccal aspect of mandible and the distance between mandibular canal and alveolar crest were examined in a frontal view radiograph of mandibular body. Two cross sectional images were selected at the level of the neurovascular bundle on the estimated 1st molar and 2nd molar area: (1) 10mm distal to the distal border of the mental foramen, (2) 20mm distal to the distal border of the mental foramen (Fig 4). Each section provided the following 5 measurements: (1) The distance from the mandibular canal to the lateral aspect of the buccal cortical plate (B) (The B measurement was used to determine how many patients had >=6mm from the IAN to the external dimension of the buccal cortical plate. The 6mm B dimensions assumed a 1mm safety zone for a 4mm diameter implant from the IAN to outer buccal plate), (2) The distance from the mandibular canal to the alveolar crest (H) (The H measurement was used to determine how many patients had >=11mm from the crest to the IAN. These dimensions >=11mm assume a 1mm safety zone for an implant 10mm in length), (3) The distance from the mandibular canal to the medial aspect of the lingual cortical plate (L), (4) The distance from the mandibular canal to inferior mandibular border (I), (5) The distance from the mandibular canal to the medial aspect to the buccal cortical plate(cancellous bone)(BC)(Fig 4).

This 1mm safety zone was reported to be sufficient to avoid neurosensory IAN problem (31).

RESULTS

Of the 40 scans 15% and 20% of patients had <11 mm H measurement and >=6mm B measurement respectively for the 1st and 2nd molar area. These patients could be candidates for a 4x10mm implant to be placed lateral to the IAN. However, in the 40 scans, 5% (1st molar) and 10% (2nd molar) of patients that had <11mm of H measurement and also <6mm of B measurement would not be candidates for a 4x10mm implant to be placed lateral to the IAN (Fig 5-10).

The summary of results is presented in Tables 1 and 2.

Fig 1. Severely atrophied posterior mandible

Fig 2. Only option is short implant or risk damage

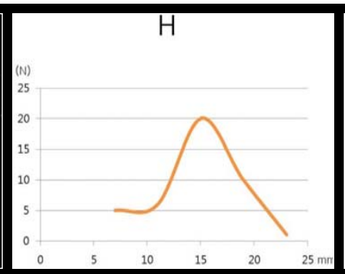


Fig 5. H (The distance from IAN to the alveolar crest)

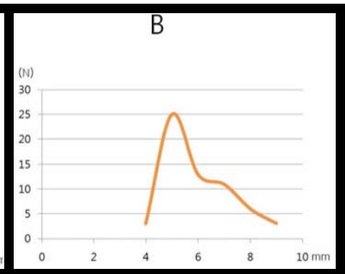


Fig 6. B (from IAN to the lateral aspect of buccal bone)

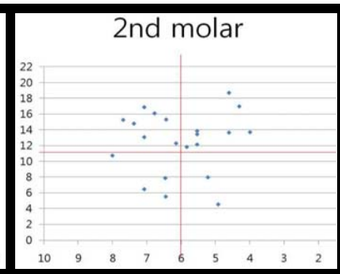


Fig 9. H and B in the second molar

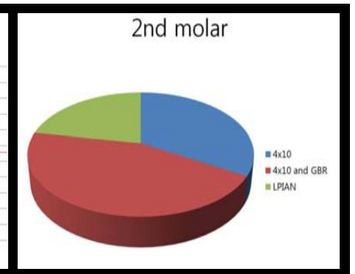


Fig 10. Possible treatment options in the second molar

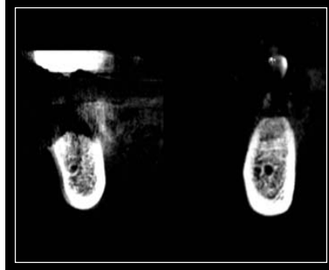


Fig 3. The position of IAN in the molar area

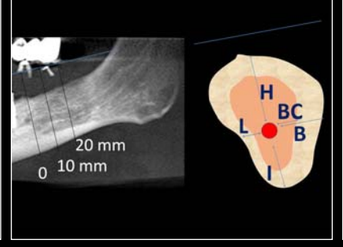


Fig 4. The measurements

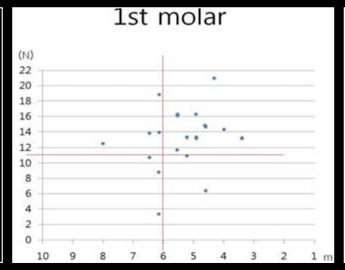


Fig 7. H and B in the first molar

Fig 8. Possible treatment options in the first molar

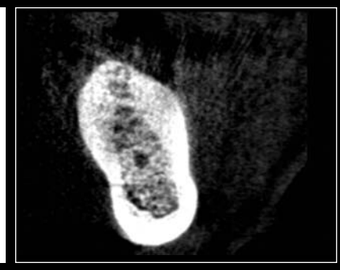


Fig 11. First molar region with limited height

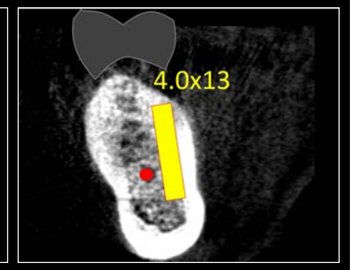


Fig 12. Simulation of a 4x10mm implant placement

DISCUSSION

The main purpose of the present study was to evaluate in what percentage of cases implants could be placed lateral to IAN. According to the results of this current study, the mean distance between the alveolar crest and the IAN in the edentulous region was 13.24 mm (range 3.40-21.00mm) in 1st molar area and 12.48mm (range 4.57-18.73 mm) in 2nd molar area respectively. The mean distance between the IAN and the buccal aspect of the buccal cortical plate (B) was found to be 5.38mm (range 3.40-8.01mm) in the 1st molar region and 6.04mm (range 4.00-8.01mm) in the 2nd molar region respectively. The result of the present study which determined the measurement of bone lateral to the IAN in the 1st and 2nd molar area agrees with those of previous study (30). Considering of 1 mm safety zone and minimal 1 mm of buccal bone to the implant surface, 4mm diameter implants can be placed lateral to IAN if B is equal to or more than 6mm. Based on this, current results can be interpreted as 15% (1st molar) and 20% (2nd molar) availability for a 4x10mm implant to be placed (Fig 11, 12). The placement of implants lateral to IAN has many advantages including reducing the need for osseous grafting or guided bone regeneration, and eliminating nerve transposition of the edentulous posterior mandible. The patient is spared the expense and morbidity of an additional surgical procedure. Another important advantage is the shortened treatment time. However, there are several considerations before utilizing out this strategy including the angulation of crown, crown-implant ratio and the amount of available cancellous bone.

Angulation of Crown

Scarfe et al (32) compared differences between restoratively projected and surgically acceptable virtual implant positions at sites identified by cylindric radiopaque markers on diagnostic templates for implant-retained mandibular overdentures using CBCT. Only 6.4% of restoratively projected positions were within the criteria for surgically acceptable implant placement. The mean angular deviation of the clinical prediction from ideal was 14.0 ± 5.5 degrees. In case where the shape and of remaining bone is not acceptable for short implants, Pancko et al (33) offered a method of treatment using tilted endosseous implants. The implants were placed penetrating both the superior buccal alveolus and the lingual cortex to achieve bicortical anchorage and avoid nerve injury. Because of the buccal location of the abutment, 24 (12.2%) of 196 implants were restored in a posterior cross bite occlusion even though they used customized abutments. When clinician plan to place implants into the bone lateral to IAN, it is recommended to consider the direction of the final crown for the better relationship of occlusion between upper and lower teeth.

Crown-Implant Ratio

Horizontal alveolar bone resorption after tooth extraction combined with vertical alveolar bone resorption. As vertical height of alveolar bone decreases, the distance between alveolar crest and occlusal plan increases. Eventually, the vertical length of final prosthesis should be longer than the length of natural crown and eventually crown-implant ratio rises. It makes vertical cantilever. The vertical cantilever affects the longevity of prosthesis.

The Width of Cancellous Bone

Clinicians should take the amount of available cancellous bone and the thickness of cortical bone into consideration when they make an osteotomy and place an implant since it is not easy to keep the direction of osteotomy when the patient has thin cancellous bone and thick cortical bone. As a consequence, the osteotomy may invade IAN and bring numbness. To avoid this kind of nerve injury, a surgical stent, which can be fixed tightly to the bone, may be considered.

IAN Injury and Safety Margin

The nerve injury is a major concern during placement. A safety margin of 2mm of osseous area in panoramic radiographic image between the implant and IAN is recommended, in order to avoid nerve injury when an implant is selected length wise. Because of its greater precision, computed tomography enables the clinician to select an implant that will be 1mm from the canal (34). Buser and von Arx (35), also, suggested that a security distance of 1 to 2mm from the mandibular canal should be respected to minimize the risk of damaging the neurovascular bundle. The risk of violation of the neurovascular bundle can be minimized using a surgical guide during placement.

There are several limitations of this study as follows :

(1) There is controversy about safety zone. Some recommend 2mm safety zone between an implant and IAN, the others recommend 1mm safety zone.
(2) Only 40 scans were included in this study.
(3) Only 1st and 2nd molar area were evaluated. Since the 3rd molar area can also be a potential site for implant placement, more study is needed about this area.
(4) Wider than 4mm diameter implants were not evaluated. If we used the wider implant, fewer cases would have been candidates for the lateral implant placement.

	1st molar	2nd molar
H	13.24 mm (3.40-21.00 mm)	12.48mm (5.47-18.73 mm)
B	5.38 mm (3.40-8.01 mm)	6.04mm (4.00-8.01 mm)
I	7.77 mm (4.99-11.81 mm)	7.62mm (5.45-12.02 mm)
L	2.97 mm (1.10-4.82 mm)	2.92mm (0.50-6.11 mm)
BC	2.50 mm (0.59-4.16 mm)	3.05mm (1.61-5.74 mm)

Table 1. Measurement (Mean & Range)

		B	
		<6 mm	>=6 mm
H<11 mm	1st molar	2 (5%)	6 (15%)
	2nd molar	4 (10%)	8 (20%)

Table 2. The number of sites & percentage (%)

CONCLUSIONS

Placing implants lateral to IAN offers an effective treatment alternative to bone grafting, guided bone regeneration, nerve lateralization, or short implants for the narrow, height deficient atrophic posterior mandible. The results of current study demonstrated that 15% of 1st molar sites and 20% of 2nd molar sites have enough lateral bone available to accommodate a 4x10mm implant.

"...the results of this current study demonstrated that 15% of 1st molar sites and a 20% of 2nd molar sites have enough bone available to accommodate at least a 4x10mm implant lateral to Inferior Alveolar Nerve (IAN)..."

REFERENCES

1. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, Head T, Lund JP, MacEntee M, Mericske-Stern R, Mojon P, Morais J, Naert I, Payne AG, Penrod J, Stoker GT, Tawse-Smith A, Taylor TD, Thomason JM, Thomson WM, Wismeijer D. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24-25, 2002. Int J Oral Maxillofac Implants 2002;17(4):601-602.
2. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
3. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. Longterm follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
4. Jemt T, Lekholm U. Oral implant treatment in posterior partially edentulous jaws: A 5-year follow-up report. Int J Oral Maxillofac Implants 1993;8: 635–640.
5. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of non-submerged ITI implants. Part I: 8-year life table analysis of a prospective multi-center study with 2359 implants. Clin Oral Implants Res 1997;8:161–172.
6. Buser D, Mericske-Stern R, Dula K, Lang NP. Clinical experience with one-stage, non-submerged dental implants. Adv Dent Res 1999;13:153–161.
7. Ferrigno N, Laureti M, Fanali S, Grippaldi G. A long-term follow-up study of non-submerged ITI implants in the treatment of totally edentulous jaws. Part I:Ten-year life table analysis of a prospective multicenter study with 1286 implants. Clin Oral Implants Res 2002;13: 260–273.
8. Garg AK, Morales MJ. Lateralization of the inferior alveolar nerve with simultaneous implant placement: Surgical techniques. Pract Periodontics Aesthet Dent 1998;10:1197–1204.
9. Misch CE, Steigmga J, Barboza E, Misch-Dietsh F, Cianciola LJ, Kazor C. Short dental implants in posterior partial edentulism: a multicenter retrospective 6-year case series study. J Periodontol 2006;77(8):1340-1347.
10. Birdi H, Schulte J, Kovacs A, Weed M, Chuang SK. Crown-to-implant ratios of short-length implants. J Oral Implantol 2010;36(6):425-433.
11. Buser D, Bragger U, Lang NP, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. Clin Oral Implants Res 1990;1:22-32.
12. Buser D, Dula K, Belser UC, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration. 1. Surgical procedure in the maxilla. Int J Periodont Restor Dent 1993;13:29–45.
13. Ilizarov GA. The tension-stress effect on the genesis and growth of tissues: Part II. The influence of the rate and frequency of distraction. Clin Orthop 1989;263-285.
14. Rosenquist B. Fixture placement posterior to the mental foramen with transpositioning of the inferior alveolar nerve. Int J Oral Maxillofac Implants 1992;7:45-50.
15. Friberg B, Ekestubbre A, Sennerby L. Clinical outcome of Bra˚nemark System implants of various diameters: a retrospective study. Int J Oral Maxillofac Implants 2002;17:671-677.
16. Bahat O. Brånemark system implants in the posterior maxilla: clinical study of 660 implants followed for 5 to 12 years. Int J Oral Maxillofac Implants 2000;15:646-653.
17. Ivanoff CJ, Grondahl K, Sennerby L, Bergstrom C, Lekholm U. Influence of variations in implant diameters: a 3 to 5-year retrospective clinical report. Int J Oral Maxillofac Implants 1999;14:173-180.
18. Reiser GF, Arnoux JP, Sarment DP. Five-mm-diameter implants without a smooth surface collar: report on 98 consecutive placements. Int J Oral Maxillofac Implants 1999;14:101-107.
19. Aparicio C, Orozco P. Use of 5-mm-diameter implants: penotest values related to a clinical and radiographic evaluation. Clin Oral Implants Res 1998;9:398-406.
20. Minsk L, Polson AM, Weisgold A, et al. Outcome failures of endosseous implants from a clinical training center. Compend Educ Dent 1996;17:848-850.
21. Sato Y, Shindo N, Hosokawa R, Tsuga K, Akagawa Y. A biomechanical effect of wide implant placement and offset placement of three implants in the posterior partially edentulous region. J Oral Rehabil 2000;27: 15-21.
22. Sato Y, Shindo N, Hosokawa R, Tsuga K, Akagawa Y. Biomechanical effects of double or wide implants for single molar replacement in the posterior mandibular region. J Oral Rehabil 2000;27:842-846.
23. Balshi TJ, Hernandez RE, Pryszlak MC, Rangert B. A comparative study of one implant versus two replacing a single molar. Int J Oral Maxillofac Implants 1996;11:372-378.
24. Ferrigno N, Laureti M, Fanali S. Inferior alveolar nerve transposition in conjunction with implant placement. Int J Oral Maxillofac Implants 2005;20(4):610-620.
25. Haers PE, Saller HF. Neurosensory function after lateralization of the inferior alveolar nerve and simultaneous insertion of implants. Oral Maxillofac Surg Clin North Am 1994;7:707–716.
26. Jensen J, Reiche-Fischel O, Sindert-Pedersen S. Nerve transposition and implant placement in the atrophic posterior mandibular alveolar ridge. J Oral Maxillofacial Surg 1994;52:662–668.
27. Kan JY, Lozada JL, Goodacre CJ, Davis WH, Hanisch O. Endosseous implant placement in conjunction with inferior alveolar nerve transposition: An evaluation of neurosensory disturbance. Int J Oral Maxillofac Implants 1997;12:463–471.
28. Kan JY, Lozado LJ, Boyne PJ, et al. Mandible fracture after endosseous implant placement in conjunction with inferior alveolar nerve transposition: A patient treatment report. Int J Oral Maxillofac Implants 1997;12:855–858.
29. Froum S, Casanova L, Byrne S, Cho SC. Risk assessment before extraction for immediate implant placement in the posterior mandible: a computerized tomographic scan study. J Periodontol 2011;82(3):395-402.
30. Yashar N, Engeland CG, Rosenfeld AL, Walsh TP, Califano JV. Radiographic considerations for the regional anatomy in the posterior mandible. J Periodontol 2012;83(1):36-42.
31. Bartling R, Freeman K, Kraut RA. The incidence of altered sensation of the mental nerve after mandibular implant placement. J Oral Maxillofac Surg 1999;57:1408-1410.
32. Wadu SG, Penhall B, Townsend GC. Morphological variability of the human inferior alveolar nerve. Clin Anat 1997;10:82-87.
33. Scarfe W, Vaughn WS, Farman AG, Harris BT, Paris MM. Comparison of restoratively projected and surgically acceptable virtual implant position for mandibular overdentures. Int J Oral Maxillofac Implants 2002;27(1):111-118.
34. Pancko F, Dyer J, Weisglass S, Kraut RA. Use of tilted implants in treatment of the atrophic posterior mandible: a preliminary report of a novel approach. J Oral Maxillofac Surg 2001;59(2):407-413.
35. Buser D, Arx T. Surgical procedures in partially edentulous patients with ITI implants. Clin Oral Implants Res 2000;11(suppl 1):63–100.

This presentation was Sponsored by:
New York University Department of Implant Dentistry Alumni Association (NYUDIDAA) and the Office for International Program