RESEARCH PAPER

CBCT-Based Selection Of Corticobasal Implant Design In Relation To The Inferior Alveolar Canal In The Posterior Mandible: A Retrospective Study In An Indian Population

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Abstract

Background: Rehabilitation of the posterior mandible using dental implants is often complicated by the proximity of the inferior alveolar nerve canal (ianc) and variations in cortical bone thickness. Corticobasal implantology offers a strategic advantage by utilizing cortical bone anchorage; however, its success depends on precise anatomical assessment using cone beam computed tomography (cbct).

Aim: To evaluate the relationship between buccal, lingual, and crestal cortical bone dimensions to the inferior alveolar canal in the posterior mandible using cbct, and to assess their influence on corticobasal implant design selection in dentulous and edentulous patients.

Materials and Methods: This retrospective observational study included 160 cbct scans (80 males and 80 females), categorized into dentulous and edentulous groups. Linear measurements were recorded: buccal cortical plate to ianc (bcpn), lingual cortical plate to ianc (lcpn), and alveolar crest to ianc (acn). Statistical analysis was performed using independent t-tests and anova with significance set at $p < 0.05$.

Results: The mean bcpn, lcpn, and acn were 6.22 ± 1.40 mm, 2.38 ± 0.66 mm, and 12.69 ± 2.01 mm, respectively. Buccal cortical bone was significantly thicker than lingual cortical bone. Male patients demonstrated slightly higher bcpn (6.37 mm) and acn (12.94 mm) compared to females. Dentulous patients exhibited greater cortical thickness (bcpn: 6.59 mm; lcpn: 2.58 mm), whereas edentulous patients showed marginally higher acn values (12.98 mm). Combined analysis revealed that male dentulous patients had the most favourable bone characteristics, while female edentulous patients exhibited the least cortical thickness.

Conclusion: Cbct-based evaluation of cortical bone dimensions relative to the ianc provides critical guidance for corticobasal implant design selection. The findings suggest that a minimum buccal or lingual bone availability of approximately 6 mm may allow safe implant placement while minimizing the risk of nerve injury. Customized implant planning based on dentition status and anatomical variations enables a more conservative, anatomy-guided approach, avoiding invasive augmentation procedures.

Keywords: Corticobasal Implants, Cbct, Inferior Alveolar Canal, Cortical Bone Thickness, Posterior Mandible, Implant Design Selection.

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INTRODUCTION

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Rehabilitation of the posterior mandible with dental implants presents significant anatomical challenges due to the proximity of the inferior alveolar canal and variations in cortical bone thickness. Accurate assessment of these anatomical structures is critical to avoid neurovascular complications and to achieve optimal implant stability. In recent years, corticobasal implantology has emerged as a reliable approach that utilizes the cortical bone for anchorage, particularly in cases with compromised alveolar bone[1].

Corticobasal implants are designed to engage the dense cortical bone rather than relying solely on cancellous bone, making them especially advantageous in atrophic ridges and edentulous patients[2]. However, successful implementation of this technique requires precise evaluation of buccal and lingual cortical bone thickness, as well as the spatial relationship to the inferior alveolar canal. Improper assessment may lead to inadequate primary stability or iatrogenic injury to the nerve[3].

The advent of cone beam computed tomography (CBCT) has significantly enhanced preoperative planning by providing three-dimensional visualization of bone architecture and vital structures[3,4]. CBCT allows accurate measurement of buccal cortical plate , lingual cortical plate , and the available crestal bone height above the inferior alveolar canal. These parameters play a crucial role in selecting the appropriate corticobasal implant design and determining the safest and most effective implant trajectory[4].

Significant alveolar bone resorption in both bucco-lingual and apico-coronal dimensions presents a formidable challenge in modern implantology. In many cases, the loss of ridge volume precludes the use of standard-length or wide-diameter implants. Furthermore, severe resorption often forces an unfavourable relationship between the residual bone and the intended prosthetic long axis, frequently bringing the site into dangerous proximity with vital anatomical structures. While traditional solutions involve invasive procedures such as nerve repositioning or horizontal/vertical ridge augmentation, these carry increased morbidity and longer healing phases[5].

Despite the increasing use of CBCT in implant planning, there is limited literature correlating cortical bone thickness and inferior alveolar nerve canal proximity with corticobasal implant design selection, particularly when comparing dentulous and edentulous patients. Furthermore, the influence of gender differences on these anatomical parameters remains inconclusive[5,6].

Therefore, the present study aims to evaluate the buccal, lingual and crestal cortical bone relationship to the inferior alveolar canal in the posterior mandible using CBCT imaging. Additionally, this study seeks to compare these parameters between dentulous and edentulous patients and assess their implications in the selection of corticobasal implant design and a more conservative, yet effective, alternative strategic modification of the corticobasal implant's safe trajectory to bypass neurovascular bundles, effectively "navigating" the anatomy rather than attempting to reconstruct it.

AIM AND OBJECTIVES

AIM

To evaluate the selection of corticobasal implant design in relation to the inferior alveolar canal in the posterior mandible using CBCT by assessing buccal , lingual ,crestal cortical bone linear distance in dentulous and edentulous patients of both the genders.

OBJECTIVES

Primary Objectives

1. To measure the linear distance of buccal cortical bone (BCPN) to inferior alveolar canal in the posterior mandible using CBCT.
2. To measure the linear distance of lingual cortical bone (LCPN) to inferior alveolar canal in the posterior mandible using CBCT.
3. To determine the vertical distance from the alveolar crest to the inferior alveolar canal (ACN) using CBCT.

Secondary Objectives

4. To compare BCPN, LCPN, and ACN between dentulous and edentulous patients.
5. To compare these parameters between male and female patients.
6. To evaluate the influence of cortical bone relationship to Inferior Alveolar Nerve Canal (IANC) proximity on corticobasal implant design selection.

MATERIALS AND METHODS

Study Design

- **Retrospective, quantitative, observational study**

Study Sample

- Total sample size: **160 patients**
  - **80 males**
  - **80 females**
- Groups:
  - Dentulous patients
  - Edentulous patients

Inclusion Criteria

- Patients aged ≥15 years

- High-quality CBCT scans of posterior mandible
- Clearly visible inferior alveolar canal
- No pathology affecting mandibular bone

Exclusion Criteria

- History of mandibular surgery or trauma
- Pathological lesions or cysts
- Poor-quality CBCT images
- Developmental anomalies

Data Collection

- CBCT scans obtained from imaging centre
- Patient identity anonymized
- Parameters measured: (Figure-1)
  - **BCPN** – Linear distance from inferior alveolar canal to nearest Buccal outer cortical bone.
  - **LCPN** – Linear distance from inferior alveolar canal nearest Lingual outer cortical bone.
  - **ACN** – Vertical Distance from Inferior Alveolar Nerve Canal to Midpoint of the Alveolar crest/ Long axis of the tooth or root.

Measurement Method

- Measurements performed using CBCT software
- Cross-sectional slices of posterior mandible analyzed
- Measurements recorded in millimeters (mm)

Statistical Analysis

- Software: SPSS / equivalent statistical tool
- Descriptive statistics: Mean ± Standard Deviation
- **Independent t-test**:
  - Male vs Female
  - Dentulous vs Edentulous
- **One-way ANOVA**:
  - Comparison among 4 groups
- Level of significance:
  - **$p < 0.05$ considered statistically significant**

TWO SAMPLE MEANS

Reference article author		
Variable of interest 1	onset of sensory block in group N	
Variable of interest 2		
Confidence Interval	C.I. %	95
Two tailed probability	$Z_{1-\alpha/2}$	1.96
Power of the study	%	80
Two Tailed probability	$Z_{1-\beta}$	0.84
Mean 1	μ_1	15.70
Standard Deviation 1	σ_1	1.90
Mean 2	μ_2	14.70
Standard Deviation 2	σ_2	2.65
Average Standard Deviation	σ	2.275
Sample Size	N	81.24571635

According to et al study, considering the mean and standard deviation of onset of sensory block in group N as 15.7 ± 1.9, mean and standard deviation of as 14.7 ± 2.65 at 95% confidence interval with 80% power, the sample size is calculated as

$$N = (Z_{1-\alpha/2} + Z_{1-\beta})^2 * 2 * \sigma^2 / (\mu_1 - \mu_2)^2$$

Z1-α/2 - two tailed proabability for 95% confidence interval = 1.96

Z1-β - two tailed proabability for 80% power = 0.84

μ1 - mean of onset of sensory block in group N = 15.7

μ2 - mean of = 14.7

σ - average standard deviation of onset of sensory block in group N & = 2.28

N = (1.96 + 0.84) ^2 * 2 * 2.275^2 / (15.7 - 14.7) ^2

N = 81.25

Thus the sample size required for each group is 81 and the total sample size is 162

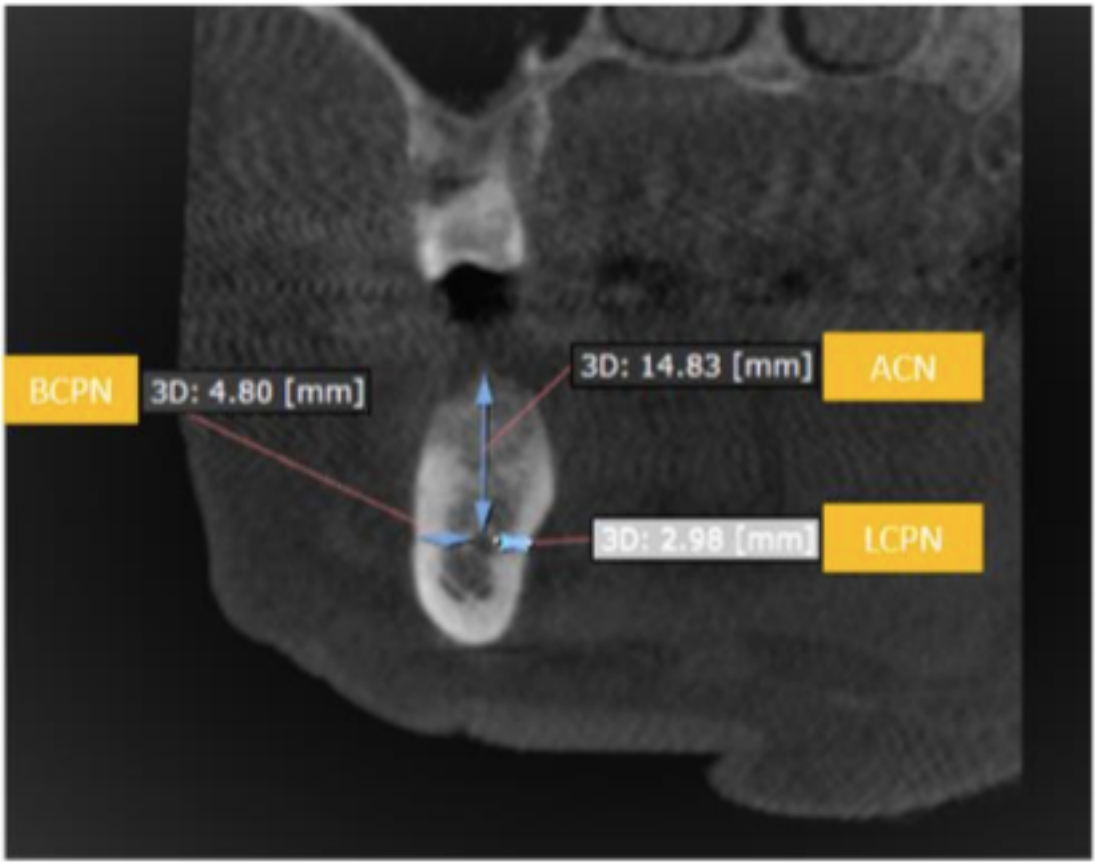
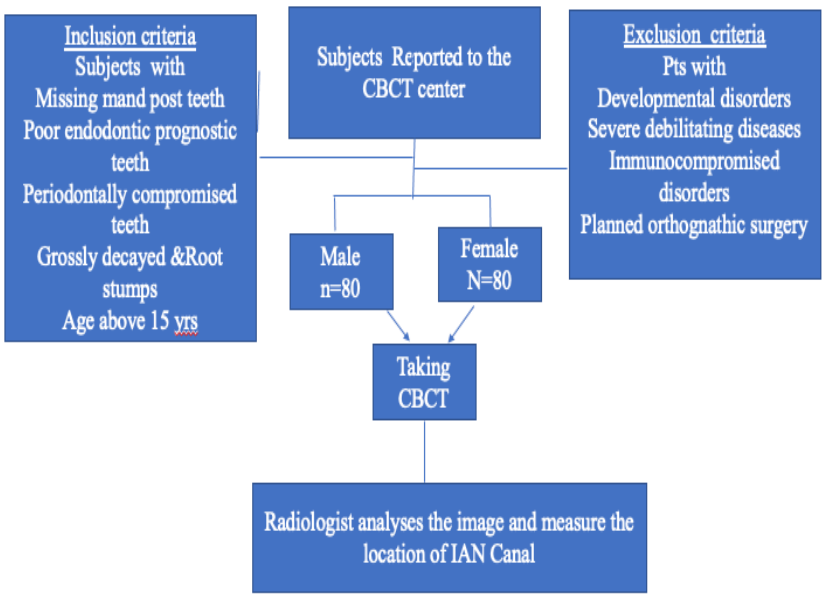


Figure-1

- **BCPN** – Linear distance from inferior alveolar canal to nearest Buccal outer cortical bone.
- **LCPN** – Linear distance from inferior alveolar canal nearest Lingual outer cortical bone.
- **ACN** – Vertical Distance from Inferior Alveolar Nerve Canal to Midpoint of the Alveolar crest/ Long axis of the tooth or root[4].

Flow chart of Methodology



RESULTS

Overall Values (n = 160)

- **BCPN (Buccal cortical bone):** Mean = **6.22 mm**, SD = 1.40
- **LCPN (Lingual cortical bone):** Mean = **2.38 mm**, SD = 0.66
- **ACN (Distance to Inferior Alveolar Canal):** Mean = **12.69 mm**, SD = 2.01
- Buccal cortex is significantly thicker than lingual cortex
- Safe vertical bone height (ACN) is generally adequate (>10 mm)

GENDER-BASED COMPARISON

Mean Values(figure- 2)

Parameter	Male	Female
BCPN	**6.37 mm**	6.07 mm
LCPN	**2.40 mm**	2.36 mm
ACN	**12.94 mm**	12.43 mm

- Males show **slightly higher cortical thickness and canal distance**
- Difference is **mild → clinically not very significant**

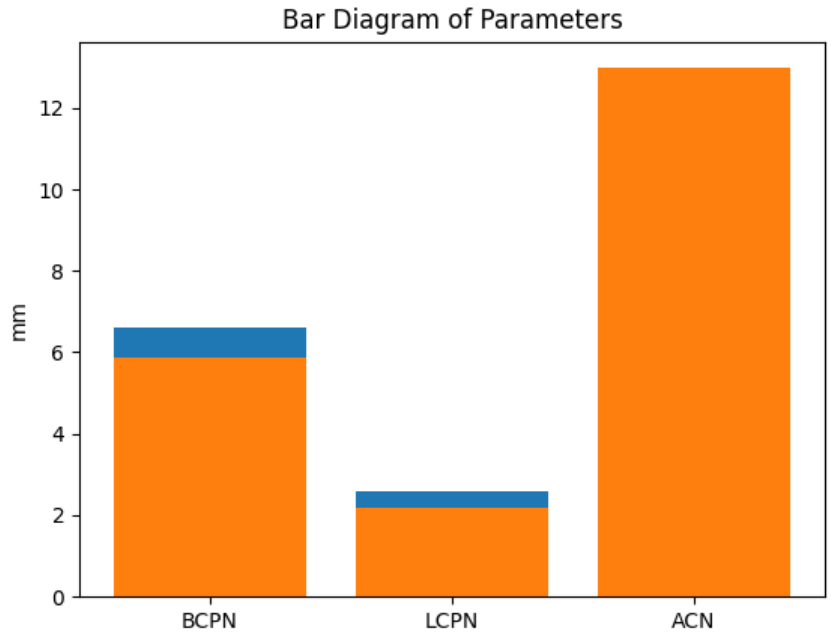


Figure-2

DENTULOUS vs EDENTULOUS

Mean Values(figure-3)

Parameter	Dentulous	Edentulous

BCPN	**6.59 mm**	5.86 mm
LCPN	**2.58 mm**	2.18 mm
ACN	12.98 M	12.98 mm

Dentulous patients → thicker cortical bone (better implant anchorage)
Edentulous patients → slightly higher ACN (more vertical safety)
Bone resorption mainly affects cortical thickness

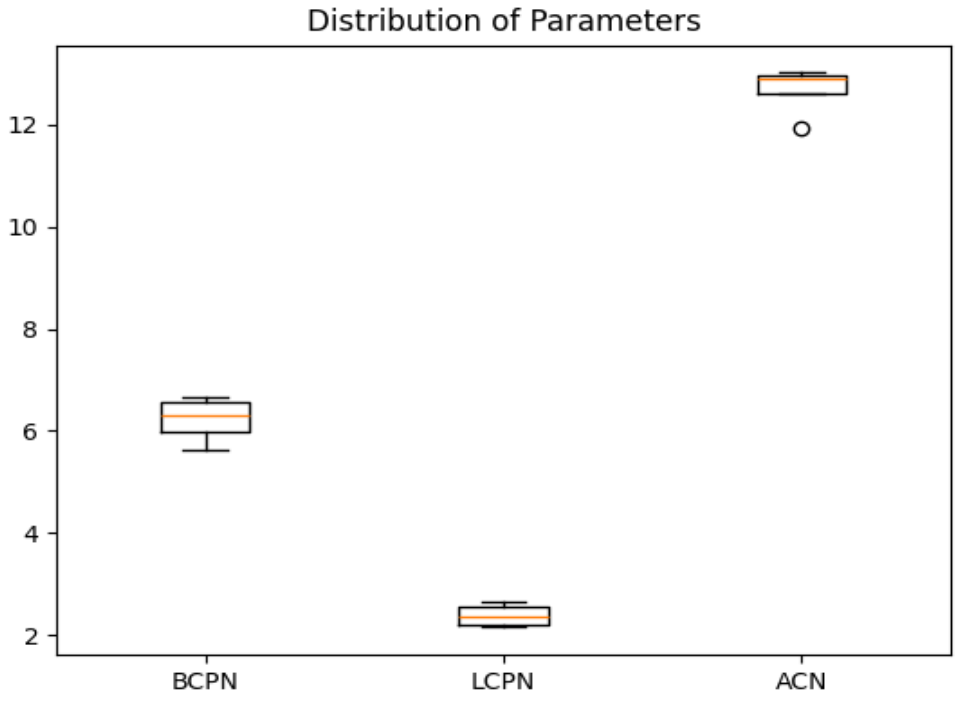


Figure-3

COMBINED GROUP ANALYSIS
Key Findings (figure-4)

- **Highest bone quality:** Male Dentulous
- **Lowest cortical thickness:** Female Edentulous
- **Greatest canal safety distance:** Male Edentulous

Selection of Corticobasal Implant design must be
customized based on bone type and dentition status

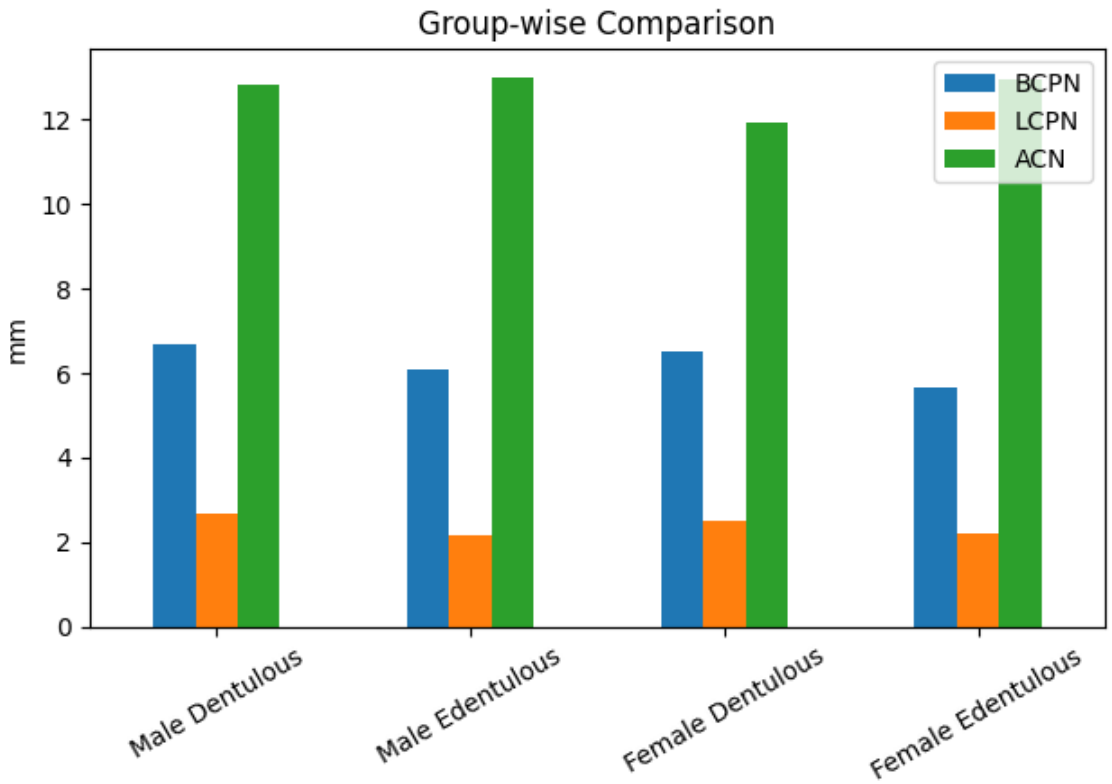


Figure-4

The mean Buccal Cortical Bone distance to IANC (BCPN) was 6.22 ± 1.40 mm, while the Lingual Cortical Bone distance to IANC (LCPN) was 2.38 ± 0.66 mm. The average Crestal Bone distance to the inferior alveolar canal (ACN) was 12.69 ± 2.01 mm.

Male patients demonstrated slightly higher BCPN (6.37 mm) and ACN (12.94 mm) compared to females (6.07 mm and 12.43 mm, respectively). Dentulous patients showed greater cortical bone thickness (BCPN: 6.59 mm; LCPN: 2.58 mm) compared to edentulous patients (BCPN: 5.86 mm; LCPN: 2.18 mm). However, ACN was marginally higher in edentulous patients (12.98 mm).

DISCUSSIONS

The present study evaluated Buccal, Lingual, Crestal cortical bone relationship to the inferior alveolar canal using CBCT for guiding selection of corticobasal implant design in the posterior mandible. The findings demonstrated that buccal cortical bone distance to IANC (BCPN) was consistently greater than lingual cortical bone distance to IANC (LCPN), which is in agreement with **G Muralidharan et al** studies emphasizing the biomechanical advantage of engaging the buccal cortex for achieving primary stability[2].

The present study findings are consistent with **Sghaireen MG et al** CBCT-based evaluations, which reported reduced cortical bone dimensions in edentulous patients due to resorptive changes. Similar to earlier observations, variations in LCPN across dentate statuses highlight the influence of age and tooth loss on bone availability. The described anatomical course of the inferior alveolar nerve, transitioning from a lingual position in the molar region to a buccal orientation in the premolar region, also correlates with our findings. While previous studies identified the premolar region as a relatively safer zone for implant placement based on LCPN values, the present study extends this concept by incorporating BCPN, LCPN, and ACN parameters into a comprehensive CBCT-based protocol for safer corticobasal implant design selection[3].

Misch CE highlighted that cortical bone plays a critical role in implant stability, particularly in posterior mandibular regions where cancellous bone density is relatively lower[7]. Similarly, **Lekholm U and Zarb GA** described the importance of bone quality and cortical engagement in implant success[8].

In the present study, dentulous patients exhibited significantly greater BCPN and LCPN compared to edentulous patients ($p < 0.001$), which is consistent with the findings of **Atwood DA**, who demonstrated that tooth loss leads to progressive alveolar bone resorption,

particularly affecting cortical bone thickness. This reduction in cortical support in edentulous patients necessitates careful Corticobasal implant design selection, often favouring engagement of threads in available cortical structures[9,14].

The lack of statistically significant gender differences observed in this study aligns with reports by **Nkenke E**, who found that site-specific bone characteristics are more critical than gender in determining implant success. This suggests that individualized CBCT-based planning is more important than demographic factors[10].

The Crestal distance to the inferior alveolar canal (ACN) showed no statistically significant difference between groups, indicating a relatively consistent anatomical safety zone. This finding is supported by **Juodzbalys G**, who emphasized that CBCT assessment is essential for avoiding nerve injury and ensuring safe implant placement in the posterior mandible[11].

The use of CBCT imaging in this study allowed precise three-dimensional evaluation of cortical bone and surrounding anatomical landmarks. **Scarfe WC and Farman AG** have demonstrated that CBCT provides superior accuracy compared to conventional radiography in implant planning, particularly in assessing bone dimensions and proximity to vital structures[12,13].

Furthermore, the significant differences observed in cortical bone parameters among the four groups (ANOVA, $p < 0.01$) highlight the importance of individualized treatment planning. **Esposito M** reported that improper implant selection without adequate anatomical assessment can lead to implant failure and complications[14].

The concept of corticobasal implantology, which relies on cortical anchorage, has been widely supported by **Ihde S**, who emphasized its effectiveness in cases with reduced bone volume[15,16].

Froum , S.J et al analyzed to assess the feasibility of implant placement either buccal or lingual to the nerve, ensuring adequate bone availability. This approach aligns with the clinical principle that a minimum bone thickness of approximately 1.5 mm should be maintained around a small diameter implant (≈3 mm) to ensure safety and stability. Similar to Froum et al observations, our study also emphasizes the importance of precise CBCT-based assessment in identifying safe zones for implant placement. However, while earlier studies primarily focused on assessing feasibility based on individual dimensions, the present study advances this concept by integrating BCPN, LCPN, and ACN into a structured protocol, thereby enhancing decision-making for corticobasal implant design selection with improved safety margins[17].

The findings of the present study are in agreement with **Lin et al** CBCT-based analyses evaluating the spatial relationship of the inferior alveolar nerve (IAN) with surrounding cortical structures. Similar to the reported study, significant variations in cortical bone availability were observed across different dentate statuses, with edentulous patients demonstrating reduced cortical dimensions. In particular, the earlier study highlighted a significant reduction in LCPN values in edentulous subjects and elderly individuals, emphasizing the influence of bone resorption and age-related changes. Our results also demonstrated comparatively lower cortical measurements in edentulous cases, reinforcing the concept that loss of dentition adversely affects cortical bone support. Furthermore, the described anatomical course of the IAN—transitioning from a lingual position in the molar region to a more buccal orientation in the premolar region—correlates with our observations, supporting the clinical relevance of buccolingual assessment during implant planning. Notably, the Lin et al suggested that the premolar region, with LCPN values exceeding 6 mm, may serve as a favourable zone for implant placement while bypassing the nerve. In contrast, our study emphasizes a more comprehensive approach by integrating BCPN, LCPN, and ACN parameters, thereby providing a structured and safer protocol for corticobasal implant design selection. Collectively, both studies underline the critical role of CBCT in pre-surgical evaluation and highlight the importance of cortical bone assessment in minimizing the risk of IAN injury[18].

The present study demonstrated that buccal cortical bone thickness was consistently greater than lingual cortical bone, which aligns with **Cho et al** & **Hansson et al** reporting that post-extraction bone resorption predominantly affects the buccal aspect more than the lingual cortex. This differential resorption pattern may be attributed to the thinner nature and reduced vascularity of the buccal plate, making it more susceptible to resorptive changes following tooth loss.

With respect to the crestal-to-inferior alveolar canal (ACN) dimension, a statistically significant difference ($p < 0.001$) was observed across all posterior regions when comparing dentulous and edentulous groups. In the present study, dentulous patients exhibited relatively higher cortical bone thickness, whereas edentulous patients demonstrated increased ACN values. This finding can be explained by the physiological process of alveolar bone resorption following tooth loss, which

primarily occurs in a coronal direction, thereby increasing the vertical distance from the alveolar crest to the inferior alveolar canal.

Collectively, these observations emphasize that while edentulous patients may present with greater vertical safety for implant placement, the reduced cortical thickness necessitates careful implant design selection. Conversely, dentulous patients offer superior cortical anchorage but may require more cautious planning in relation to canal proximity. These anatomical variations highlight the importance of CBCT-based individualized treatment planning in corticobasal implantology[19,20].

The present study reinforces this concept by demonstrating the clinical relevance of Buccal, Lingual, Crestal cortical bone relationship to IANC in implant design selection Posterior mandible region.

Overall, the findings of this study are consistent with existing literature and further emphasize that CBCT-based evaluation of cortical bone distance and canal proximity is essential for safe and effective corticobasal implant placement in the posterior mandible.

STANDARDIZED PROTOCOL FOR CORTICOBASAL IMPLANT DESIGN SELECTION

- **Implant Diameter and Buccal Bypass**: In the posterior mandible, the buccal-nerve distance (approx 6 mm) is the "safety zone." Corticobasal implants should be selected with a diameter that allows to get engage in crestal , buccal and inferior cortical bone (Tricortical engagement) after bypassing IANC. (single piece rough surface with long polished neck compressive type of corticobasal implant design.
- **Lingual Cortical Engagement:** when the LCPN is significantly smaller than the BCPN, implants designed for bi-cortical engagement (single piece smooth surface) must be engaged in lingual cortical bone superior to IANC. Lingual engagement inferior to the IANC poses a heightened risk of nerve injury, abutment bending hindrance and submandibular space penetration due to close anatomical proximity.
- **Implant Length**: For standard vertical placement, length of >10 mm is safe for most patients. However, for those with an ACN of <10 mm (found in several dentulous cases), short implants or Buccal Bypass techniques where apical tip should be engaged in inferior border of posterior mandible is preferred. Bending of implant abutment heads are avoided in corticobasal implants height <10 mm. Oblique implant placement engaging the lingual cortical bone permits the use of longer smooth BCS implants, thereby enhancing cortical anchorage and primary stability.
- **Basal Design in Narrow Ridge :**The significant reduction in horizontal bone in edentulous ridges may need thinner-threaded corticobasal implants or those with a specific pitch to engage the denser basal bone without stressing the resorbed cortical plates. (narrow smooth implant as a supportive implants rather than loadbearing implants and/ or Two narrow smooth surface implants with Syncrystallization of Implant abutment heads by bending or with Two Numbers of 1.5 mm diameter Titanium wires vertically one above the other to bear the occlusal load either in shank or abutment heads of the implants)

EVIDENCE-BASED CRITERIA FOR CORTICOBASAL IMPLANT PLACEMENT

Zone	Action	Rationale
Superior Lingual cortical Engagement (Superior to IANC)	**Engaged**	Provides immediate horizontal stability and anti-rotation.
Buccal Bypass	**Executed**	Navigates the implant shank safely past the IANC.
Inferior Border of Posterior mandible after IANC Buccal Bypass	**Engaged (Tip)**	Terminal D1 anchor for vertical load-bearing.
Inferior Lingual cortical Engagement (Inferior to IANC)	**Avoided**	**Risk Mitigation:** Prevents submandibular space invasion , Abutment Bending hindrance, Technique sensitive , etc

CONCLUSION

CBCT-based evaluation demonstrates that corticobasal implant design selection should be guided by Buccal , Lingual and Crestal cortical bone and proximity to the

Inferior Alveolar Nerve Canal. Dentulous patients exhibit superior cortical bone support, favouring enhanced implant stability, while edentulous patients present relatively increased vertical safety from the canal. Gender differences are minimal and clinically less significant. Therefore, Individualized Corticobasal implant design selection based on CBCT parameters is essential for optimal outcomes in posterior mandibular rehabilitation.

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