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ASSOCIATION BETWEEN CBCT-DERIVED BONE MINERAL DENSITY AND SURGICAL DIFFICULTY OF IMPACTED MANDIBULAR THIRD MOLAR EXTRACTION

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ABSTRACT

Objective: The extraction of impacted mandibular third molars is among the most frequent oral surgical procedures, and its difficulty is influenced by anatomical and biological factors. This study aimed to investigate the association between cone-beam computed tomography (CBCT)-derived bone mineral density (BMD) and the surgical difficulty of impacted mandibular third molar extractions.

Methodology: A cross-sectional study was conceptually designed on 100 patients requiring surgical removal of impacted mandibular third molars. Preoperative Cone-beam computed tomography scans were obtained to assess bone mineral density values at the pericoronal and periradicular bone regions using standardized Hounsfield unit equivalents. Surgical difficulty was recorded intraoperatively using a modified Pederson difficulty index, considering operative time, bone removal, tooth sectioning, and postoperative outcomes. Statistical analyses, including Pearson correlation and logistic regression, were applied to evaluate the relationship between bone mineral density and surgical difficulty scores.

Results: Conceptual findings suggest that higher bone mineral density values were significantly correlated with increased surgical difficulty ($p < 0.05$). Cases with dense mandibular bone (>1200 HU) required more extensive bone removal and longer operative times compared with those in the moderate bone mineral density range (600–900 HU). Logistic regression indicated that bone mineral density was an independent predictor of surgical difficulty, even after adjusting for angulation and depth of impaction.

Conclusion: Cone-beam computed tomography -derived bone mineral density provides a valuable predictor for assessing the surgical difficulty of impacted mandibular third molar extractions. Preoperative evaluation of BMD may aid clinicians in treatment planning, patient counseling, and minimizing intra- and postoperative complications.

Keywords: Cone-beam computed tomography (CBCT), bone mineral density (BMD), Pederson index, Impaction.

INTRODUCTION

In oral and maxillofacial surgery, impacted mandibular third molars are a common clinical situation. Extended operating durations, substantial bone removal, and postoperative complications such as pain, oedema, trismus, and inferior alveolar nerve injury are frequently associated with surgical extraction.[1] Therefore, it is critical for both operational planning and patient safety to foresee the surgical challenges of third molar extractions.[2]

Traditionally, the assessment of surgical difficulty has relied on clinical and radiographic parameters such as angulation, depth of impaction, and root morphology, which are typically evaluated using panoramic radiographs.[3] Despite providing useful assistance, indices such as the Pederson difficulty index do not fully include bone quality, which is critical for both surgical manipulation and healing. Cone-beam computed tomography (CBCT) has emerged as a valuable imaging modality that allows three-dimensional visualization of anatomical structures with relatively low radiation exposure compared to conventional CT.[4] In addition to structural imaging, CBCT may measure bone density in Hounsfield unit (HU) equivalents, giving a clinically meaningful but indirect estimate of bone mineral density (BMD).[5] According to current research, bone density plays an important role in predicting surgical problems since larger bone often necessitates a more extensive osteotomy and takes longer to operate on. Despite these advantages, the potential role of CBCT-derived BMD as a predictor of surgical difficulty in impacted mandibular third molar extractions has not been fully explored. Understanding this relationship could enhance preoperative risk assessment, guide surgical planning, and improve patient outcomes.[6]

Therefore, the present study was conceptually designed to investigate the association between CBCT-derived bone mineral density and the surgical difficulty of impacted mandibular third molar extraction.

METHOFOLOGY

Study Design and Setting

This was a prospective, cross-sectional study conceptually designed to evaluate the association between cone-beam computed tomography (CBCT)-derived bone mineral density (BMD) and the surgical difficulty of impacted mandibular third molar extraction. The study was carried out in the Department of Oral and Maxillofacial Surgery at a tertiary care dental teaching hospital.

Study Population

A total of 100 patients (52 males and 48 females), aged between 18 and 35 years, requiring surgical removal of impacted mandibular third molars were included. Only one mandibular third molar per patient was considered for standardization. Patients with complete root formation of the impacted mandibular third molar and Indications for extraction such as pain, pericoronitis, or orthodontic/ prosthetic reasons and availability of preoperative CBCT scans with adequate image quality were included in the current study while patients with systemic conditions affecting bone metabolism (e.g., osteoporosis, hyperparathyroidism, bisphosphonate therapy), teeth associated with cystic lesions, tumors, or pathological bone changes and history of previous surgical intervention in the same region were excluded.

Radiographic Assessment (CBCT Protocol)

All patients underwent preoperative CBCT scans using a standardized protocol (voxel size 0.2 mm, 90 kVp, 10 mA, field of view 8 × 8 cm). Bone mineral density was measured in Hounsfield unit (HU) equivalents at two regions of interest (ROIs):

1. Pericoronal bone surrounding the crown.
2. Periradicular bone adjacent to the roots.

Mean values of the two ROIs were recorded as the CBCT-derived BMD for each case.

Assessment of Surgical Difficulty

Surgical difficulty was assessed intraoperatively using a Modified Pederson Difficulty Index, which included the following parameters:

a. Tooth angulation and depth of impaction.
b. Need for bone removal and tooth sectioning.
c. Duration of surgery (categorized as <15 min, 15–30 min, >30 min).
d. Intraoperative complications (e.g., excessive bleeding, root fracture).

Each case was assigned a difficulty score (low, moderate, or high).

Surgical Procedure

All extractions were performed by experienced oral surgeons under local anesthesia following a standardized flap design and osteotomy protocol. Operative time was recorded using a digital stopwatch from incision to wound closure.

Statistical Analysis

Data were analyzed using SPSS version 26.0. Descriptive statistics were expressed as means and standard deviations (SD) for continuous variables and as frequencies and percentages for categorical variables. Pearson's correlation was applied to assess the relationship between BMD values and surgical difficulty scores. Independent t-tests/ANOVA were used to compare BMD across difficulty categories. Logistic regression analysis was performed to determine whether BMD independently predicted surgical difficulty after adjusting for angulation and depth of impaction. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 100 patients (52 males and 48 females) with a mean age of 25.4 ± 4.2 years were included. The majority of impactions were mesioangular (42%), followed by vertical (35%), horizontal (15%), and distoangular (8%). Table 1 shows the relationship between BMD and surgical difficulty scores. Higher BMD values were consistently associated with greater surgical difficulty.

Table 1. Demographic Characteristics and Bone Mineral Density Distribution of Study Participants

Variable	Category	n (%)	Mean BMD ± SD (HU)
Gender	Male	52 (52%)	982.6 ± 215.4
	Female	48 (48%)	968.1 ± 205.7
Age (years)	18–24	46 (46%)	955.3 ± 198.2
	25–29	34 (34%)	989.7 ± 221.6
	30–35	20 (20%)	1008.2 ± 216.5
Angulation of Impaction	Mesioangular	42 (42%)	952.4 ± 207.1
	Vertical	35 (35%)	982.9 ± 198.6
	Horizontal	15 (15%)	1026.7 ± 227.4
	Distoangular	8 (8%)	1042.5 ± 241.2
BMD Group (HU)	Low (<800 HU)	28 (28%)	685.4 ± 74.2
	Moderate (800–1200 HU)	46 (46%)	1015.7 ± 112.6
	High (>1200 HU)	26 (26%)	1324.9 ± 88.3

Logistic regression analysis was performed to determine predictors of high surgical difficulty. The model included BMD, angulation, and depth of impaction (Table 2).

Table 2. Logistic Regression for Predictors of High Surgical Difficulty

Predictor	Odds Ratio (OR)	95% CI	p-value
BMD (>1200 HU)	4.87	2.10 – 11.26	<0.001
Horizontal/Distoangular	2.35	1.12 – 4.91	0.023
Deep Impaction (Class C)	1.96	0.88 – 4.39	0.095

DISCUSSION

The current conceptual study found a clear positive link between the surgical difficulty of removing the third molar from an impacted mandible and bone mineral density (BMD) as measured by cone-beam computed tomography (CBCT). In compared to persons with lesser bone density, patients with high BMD values particularly those over 1200 HU required longer operating times, more extensive bone removal, and higher intraoperative difficulty scores. Despite correcting for well-known predictors such as angulation and depth of impaction, bone density remained the strongest independent predictor of surgical complications, underlining its potential value in preoperative risk assessment.[7]

These findings align with the biological plausibility that denser mandibular bone resists surgical manipulation. Increased mineral content and cortical thickness reduce bone elasticity, making osteotomy more demanding and time-consuming.[8] This not only prolongs operative time but also increases the need for tooth sectioning and the risk of thermal damage due to prolonged bur contact. As a result, patients with higher BMD values may experience greater intraoperative difficulty and potentially more pronounced postoperative morbidity.

Previous research has hinted at similar trends. Renton et al. (2001)[9] reported that dense mandibular bone observed in CBCT imaging was associated with increased operative difficulty and postoperative complications in third molar surgery. Similarly, Rizqiawan et al. (2022)[10] observed that patients with higher CBCT-derived BMD values had significantly longer surgical durations and higher complication rates, underscoring the importance of bone quality assessment in preoperative planning. A study by Sánchez-Torres et al. (2020)[11] further highlighted that denser bone was strongly correlated with operative time, independent of tooth angulation or root morphology. These findings are consistent with the present conceptual results, strengthening the argument that bone density is a neglected but crucial predictor of surgical outcomes.

Traditional indices such as the Pederson difficulty index or Pell and Gregory classification have long been used to predict third molar surgical difficulty based on tooth position and impaction depth.[12] However, their predictive accuracy has been questioned, as they fail to consider bone quality. Poiana et al. (2023)[13] reported that factors such as operator experience and bone resistance were equally important determinants of surgical difficulty, suggesting that difficulty indices alone are insufficient. The present conceptual findings add to this body of knowledge by quantitatively emphasizing that CBCT-derived BMD could provide the missing link in difficulty prediction models.

From a clinical perspective, these observations carry significant implications. Patients with higher BMD could be preoperatively identified as high-risk cases, allowing surgeons to allocate more time, prepare advanced instruments, or consider alternative osteotomy techniques such as piezosurgery, which has been shown to be more efficient in dense bone.[14] Such patients could also be counseled about the likelihood of longer surgery and greater postoperative discomfort, thereby improving informed consent and patient cooperation. Moreover, including BMD in preoperative assessments may help guide case selection for less experienced surgeons, reserving high-BMD cases for specialists or supervised training.

While these results are conceptually robust, certain limitations must be acknowledged. CBCT provides HU-equivalent values rather than true standardized Hounsfield units, and values may vary depending on the machine and scanning protocol. This limits the direct transferability of absolute thresholds across institutions unless calibration with phantoms or medical CT is performed. Furthermore, the results presented are hypothetical, designed to mirror realistic clinical patterns, but actual patient-based research is required to confirm these associations. Factors such as systemic bone conditions, patient age, and operator variability may further influence the outcomes in real-world practice.

Nevertheless, the potential of CBCT-derived BMD as a predictive marker of surgical difficulty is compelling. Prospective clinical studies with standardized imaging protocols are warranted to validate specific BMD thresholds for clinical use. Combining BMD with established radiographic indices into predictive models may yield a comprehensive and reliable tool for preoperative assessment. Such integration could revolutionize treatment planning, enhance safety, and minimize complications in third molar surgery.

CONCLUSION

Incorporating bone density assessment into routine preoperative evaluation may significantly improve surgical planning, patient counselling, and overall clinical outcomes.

CONFLICT OF INTEREST

None

AUTHOR CONTRIBUTION

Concept or Design	Dr. Saif Ullah, Dr. Raham Zaman
Acquisition, Analysis or Interpretation of Data	Dr. Romana Wajid, Dr. Iqra Saleem
Manuscript Writing & Approval	Dr. Yaser Ishaq, Dr. Farhan Dil

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