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Original Article

Imaging-Based Determination of Optimal Sectioning Parameters for Coronectomy in Impacted Mandibular Third Molars

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ABSTRACT

Coronectomy is a less hazardous option than extraction for third molars that pose an elevated risk of damaging the inferior alveolar nerve. Nevertheless, the procedure can still lead to complications due to the lack of uniform, effective tooth-sectioning methodologies. We advanced a standardized protocol for third molar coronectomy, with uniform tooth sectioning parameters to reduce potential complications, operative failure, and the need for subsequent interventions. The research was executed on 69 suitable archived CBCTs. The mandibular coronal sections at the foremost level of the lower third molar served to ascertain diverse axes and reference landmarks. This was performed to define the target angle and depth for the coronectomy cut. Depth and angle data for the sectioning were conveyed as means and standard deviations. A multivariate analysis of variance was employed to assess the effects of the study variables on drill depth and angle. Linear regression and correlation among the study variables were also used to predict the drill depth and angle. The sample comprised 46 males and 23 females, aged 21 to 47 years. The mean drill angle was calculated as 25.01 ± 3.28. The mean drill depth was 9.60 ± 9.90 mm. Bucco-lingual inclination exerted a notable influence on drill depth, $F(1, 62) = 5.15$, $P < 0.05$, yet no meaningful impact on drill angle, $F(1, 62) = 29.62$, $P > 0.05$. The outcomes imply that a uniform sectioning protocol can prove efficacious during operative coronectomy procedures. The drill is to be executed at a 25-degree angulation to a depth of 9.5 mm to attain the desired results. Such an approach will ensure that no residual enamel remains, reduce the risk of root displacement and subsequent surfacing, and improve the outcome.

Keywords: Impacted third molar, Coronectomy, Inferior alveolar nerve, Complications, Oral surgery

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Introduction

The excision of symptomatic impacted third molars is the most prevalent operative procedure in oral surgery. There are numerous reasons for extracting impacted mandibular third molars, though the most common is a recurrent infection of the erupting tooth crown, known as pericoronitis. Hence, the chief therapeutic advantage of operative removal is the mitigation of pericoronitis symptoms and manifestations along with its likely sequelae. That said, this operation is linked to a notable incidence of complications, among them potential trauma to the inferior dental nerve [1-3]. Coronectomy constitutes an operative protocol that excises the dental crown alongside a segment of the root yet conserves the apical root portion adjacent to the inferior dental canal. It was originally presented as a substitute for full extraction when the roots of the third molar lie in close association with the inferior dental canal [4]. According to the PubMed database, by March 2024, 157 research papers had been published on third molar coronectomy. Examination of the timeline reveals that this method attracted the most attention from 2018 to

2020, yielding an average of 19 papers per year. The most frequent publication format was reviews, including systematic reviews, accounting for 24 (15.3%) of the entire corpus. Clinical investigations accounted for only 13 (8%) of the total, resulting in 7 (4.5%) meta-analyses that focused chiefly on publications from 2002 to 2010. Virtually all clinical investigations and reviews have indicated that coronectomy is applicable for addressing third molars carrying elevated operative neurological hazards [5-9]. Although the operative technique of coronectomy has been refined over the past two decades, some authors have highlighted the need for further refinements to reduce complications and failures [10, 11]. These latter concerns pertain to the root remnants retained in place, arising from specifics in tooth sectioning depth and angulation. Multiple methods and proposals have been set forth to alleviate drilling-related complications during operative coronectomy of the third molar. These comprise dynamic image-based navigation [12] and 3D-fabricated drilling guides [13]. These could be harnessed in simulation-based training to standardize the approach and enhance self-confidence among junior oral surgeons. The practical application of these methods was limited to preclinical settings and to small case series, which often lacked control arms. The authors underscored the difficulties they encountered with these approaches, including the need for substantial buccal and distal bone resection. This protracted operative duration could correlate with heightened post-surgical morbidity and relies predominantly on the employment of angled high-speed burs rather than uniform straight surgical handpieces. This is apt to result in a shallower drilling depth, compromising root stability throughout the coronectomy. In the end, these strategies rely heavily on supplementary technology, subjecting patients to excess radiation, prolonging wait times for individuals in discomfort, and incurring additional costs for both patients and the health system. Deploying these methods during simulation-based training can strengthen junior oral surgeons' capabilities and confidence in undertaking standardized operative procedures.

In light of the prevailing literature and clinical practice, coronectomy is predominantly performed following a limited set of publications outlining the initial method and its subsequent adjustments, informed by the judgment of a handful of expert practitioners. However, there remains a lack of published research explaining how the coronectomy sectioning angle and depth can be carried out reproducibly to achieve the intended standardized result. Additionally, every radiological report noted that the earlier surgery was guided, which is challenging within existing operative frameworks. This study aimed to establish standard tooth-cutting angles and depths to achieve the ideal size and position of the remaining root fragment. This was achieved by examining a sizeable collection of impacted mandibular third molars from both sexes via radiological assessment of stored scans. The intention is to curtail the possible complications liable to provoke operative coronectomy failure and mandate an extra procedure to extract the persisting dental roots of third molars.

Materials and Methods

The present work was executed at the College of Dental Medicine, University of Sharjah, United Arab Emirates. The University Research Ethics Committee granted ethical clearance for the study (approval number REC-23-09-07-03-F). A total of 400 mandibular Cone Beam CT scans (CBCT) were reviewed. No extra CBCT imaging was commissioned for this study. Patient identification was not possible from the gathered information. All study data were managed and archived in accordance with the university's data safeguarding policies. The CBCT acquisitions were performed on a Galileos CBCT unit (Bensheim, Germany). Imaging employed a 15 × 24 cm Field of View (FOV) (voxel dimension 0.25 mm). The unit settings were 85 kVp and 7 mA. Interpretation of the 3D volumes was performed on a 1,920 × 1,080-pixel, 23-inch HP monitor. A solitary dental radiologist with a decade of professional experience assessed the CBCT scans. Scans demonstrating complete coronal and radicular coverage of mandibular third molars qualified for inclusion. Those displaying incomplete anatomical visualization of the region of interest (ROI), absent lower third molars, pathological findings, or imaging artifacts within the mandibular third molar zone were omitted.

Parameter calculation was carried out on the coronal slice of the 3D acquisition. The reference point for standard measurement was the most anterior coronal slice providing full crown and mesial root representation. A line originates at the CEJ on the lingual face of the 3rd molar (point A) and runs to point B, which lies 4 mm apical to point A along the periodontal ligament space on the Coronal CBCT slice. Point B defines the target sectioning depth for the coronectomy, aimed at counteracting possible coronal root migration and subsequent root emergence through the oral mucosa (i.e., re-eruption). The decision to adopt a 4 mm depth for sectioning was based on an extensive systematic review and meta-analysis

encompassing 13 clinical studies that examined residual root migration. The outcomes of those investigations revealed a mean root migration of 2.8 mm [6, 7], prompting the conclusion that this sectioning depth offered the most favorable means of reducing root fragment eruption risk and the subsequent necessity for extraction. Point C is sited on the buccal side of the 3rd molar at the plane of the cementoenamel junction, arranged so that AC runs parallel to the occlusal table. The latter represents the likely point of drill entry for tooth sectioning from the buccal direction. Angle ACB corresponds to the intended angulation of the drill axis, ensuring the sectioning depth aligns with target point B; within this study, it is designated the Drill Angle (DA). The span from point B to C is additionally quantified to establish the Drill Depth (DD). This span is characterized as the optimum distance to achieve near-total tooth transection in the buccolingual axis without perforation of the socket's lingual plate and consequent lingual nerve injury, while also guaranteeing zero root displacement upon separation of the coronal segment. To complete the transection, the sloped buccal portion of the root remnant must be leveled down to the plane of point A. The angle EGF, formed at the deepest point on the occlusal table by the two lines (outlined below), is gauged to ascertain the Bucco-Lingual Tilt (BLT); (1) Long axis of the 3rd molar, depicted by line GF, and (2) The vertical perpendicular line dropped from the deepest point on the occlusal surface, shown by line GE (**Figure 1)**.

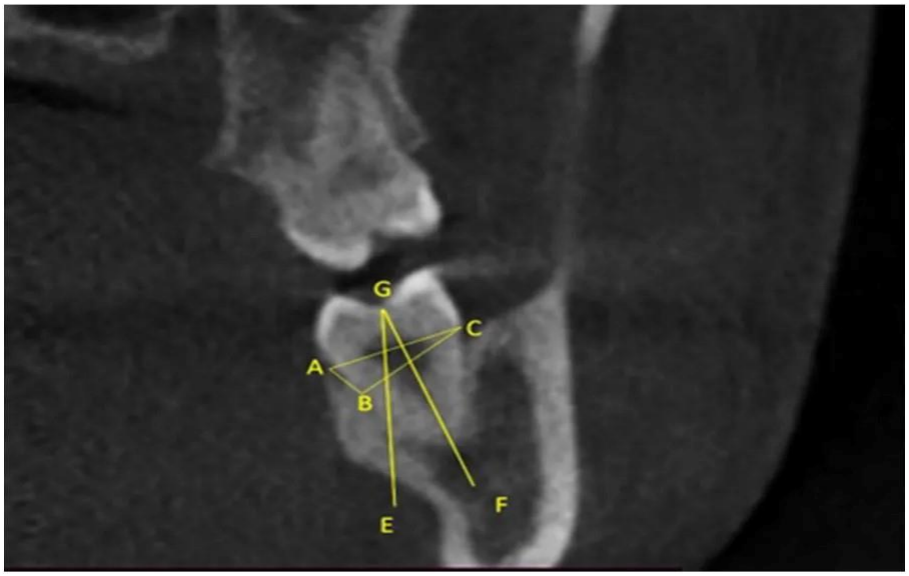

Figure 1. The coronal cross-section of an impacted mandibular third molar, showing the distinct axes and angulations utilized for this investigation.

All recorded information was compiled in a Microsoft Excel spreadsheet and analyzed with IBM SPSS Statistics, Version 22 (Armonk, NY: IBM Corp). For continuous variables, descriptive data were reported as mean and standard deviation. To assess the effect of the study variables on both drill depth and angle, Multivariate Analysis of Variance (MANOVA) was applied. Pearson's correlation coefficient measured the strength of associations among the study variables, while linear regression was used to predict drill depth and angle based on those variables. Statistical significance was set at $P < 0.05$.

A pilot evaluation was conducted on 10 CBCT scans that met the eligibility criteria to gauge sample size. Given a standard deviation of 1.6, a margin of error of 0.5, and an alpha error of 1%, the required sample size was computed to be 69 scans.

Results and Discussion

A single examiner reviewed every scan. That same examiner re-assessed 10% of the scans drawn from the total analyzed pool following a 15-day hiatus. Intra-examiner reliability (intraclass correlation coefficient, ICC) was 0.94.

Study population

A synopsis of the study population's attributes is laid out in **Table 1**. Of the 400 CBCT scans, 69 met the inclusion criteria. The sample encompassed 46 males (66.7%) and 23 females (33.3%). The age range was 21 to 47 years, with a mean of 31. The predominant age group was individuals under 30, with 30 participants (43.5%), followed by those in their fourth decade, with 29 participants (39.1%).

Table 1. Summary statistics for drill angulation and penetration depth stratified by patient age and sex.

Age group (years)	Gender	SD (drill depth)	Mean drill depth	SD (drill angle)	Mean drill angle	N
19–30	Male	0.95	9.79	3.05	24.26	22
	Female	1.08	9.41	3.43	25.60	8
	Total	0.98	9.69	3.15	24.62	30
31–40	Male	0.76	9.48	2.89	25.44	16
	Female	1.07	9.39	4.87	25.16	11
	Total	0.88	9.44	3.73	25.33	27
> 40	Male	0.70	9.63	2.92	25.64	8
	Female	0.85	10.01	1.85	24.63	4
	Total	0.74	9.76	2.57	25.30	12
Overall	Male	0.84	9.65	2.97	24.91	46
	Female	1.02	9.50	3.88	25.22	23
	Total	0.90	9.60	3.28	25.01	69

Std. Dev: Standard Deviation.

Drill angle and drill depth

The recorded drill angle averaged 24.9 ± 2.97 among male subjects and 25.2 ± 3.88 among female subjects, producing a total mean of 25.01 ± 3.28. Drill depth averaged 9.65 ± 8.84 in males and 9.50 ± 1.02 mm in females, with a collective mean depth of 9.60 ± 9.90 mm.

As determined by Pillai's trace, no statistically meaningful consequences were attributable to age, $V = 0.04$, $F(4, 124) = 0.61$, $P > 0.05$, sex, $V = 0$, $F(2, 61) = 0.01$, $P > 0.05$, or bucco-lingual angulation, $V = 0.08$, $F(2, 61) = 2.53$, $P > 0.05$, with respect to drill angle and drill depth **(Table 2)**. Individual univariate ANOVAs on the dependent measures (drill angle and drill depth) indicated that age and sex did not contribute significantly ($P > 0.05$). On the other hand, bucco-lingual angulation exerted a significant effect on drill depth, $F(1, 62) = 5.15$, $P < 0.05$, whereas its influence on drill angle remained non-significant, $F(1, 62) = 29.62$, $P > 0.05$ **(Table 3)**. **Table 4** displays a weak inverse relationship identified between drill depth and bucco-lingual angulation ($r = -0.28$, $P = 0.02$). **Figure 2** presents a schematic overview of the proposed tooth sectioning guide, supplemented by an illustrative case treated consistent with the study's findings.

Table 2. Relationships between drill angulation and penetration depth and the examined variables: multivariate analyses evaluating the impact of the study variables on drill angle and drill depth.

Effect	P-value	Error df	Hypothesis df	F	Value
Intercept	< 0.001*	61	2	4,358.21	0.99
Bucco-lingual tilt	0.09(NS)	61	2	2.53	0.08
Age	0.66(NS)	124	4	0.61	0.04
Gender	0.99(NS)	61	2	0.01	0
Age* Gender	0.81(NS)	124	4	0.4	0.03

Pillai's Trace, Design: Intercept + Bucco-lingual tilt + Age + Gender + Age Gender.
$P < 0.05$ Statistically Significant.

Table 3. To assess the association between drill angulation and depth and the study variables, linear regression was used to estimate drill angle from the study variables.

Predictor	95% CI upper	95% CI lower	P-value	t-value	Beta (Standardized)	Std. Error	B (Unstandardized)
Constant	56.22	41.96	<0.001*	13.76	—	3.57	49.09
Age	0.11	−0.01	0.08 (NS)	1.79	0.15	0.03	0.05
Gender	1.06	−1.18	0.91 (NS)	−0.11	−0.01	0.56	−0.06
Bucco-lingual tilt	0.07	−0.06	0.87 (NS)	0.17	0.01	0.03	0.01
Drill depth	−2.08	−3.31	<0.001*	−8.71	−0.74	0.31	−2.70

Dependent Variable: Drill angle, $F(4,68) = 22.15$, $P < 0.001$, $R2 = 0.58$.
$P < 0.05$ Statistically Significant.

Table 4. Relationship between drill angulation and depth, and the study variables: linear regression applied to forecast drill depth from the study variables.

Predictor	95% CI upper	95% CI lower	P-value	t-value	Beta (standardized coefficients)	Std. Error	B (unstandardized coefficients)
Constant	15.94	13.47	< 0.001*	23.82	—	0.62	14.70
Age	0.02	−0.01	0.38	0.88	0.07	0.01	0.01
Gender	0.23	−0.38	0.62	−0.50	−0.04	0.15	−0.08
Bucco-lingual tilt	0.01	−0.03	0.15	−1.46	−0.12	0.01	−0.01
Drill angle	−0.16	−0.25	< 0.001*	−8.71	−0.73	0.02	−0.20

Dependent Variable: Drill depth, F(4, 68) = 22.44, P < 0.001, R2 = 0.58.
P < 0.05 Statistically Significant.

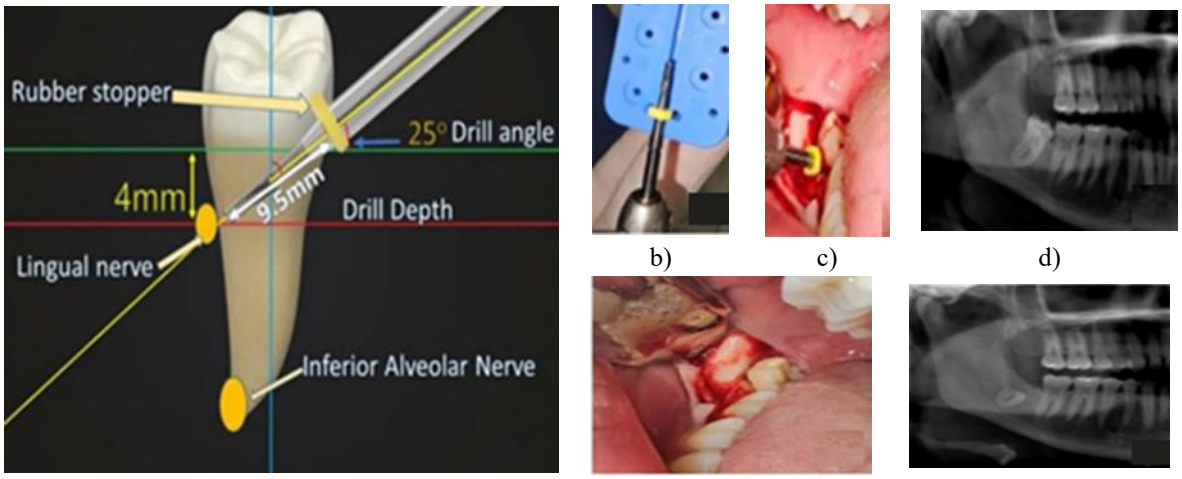

Figure 2. A walkthrough of the proposed tooth sectioning guide using a worked clinical example (a) The drawing lays out a sectioning approach where the bur penetrates to 9.5 mm at a 25° deviation from the long axis, ensuring the crown is fully detached and a root stump stays 4 mm below the level of both cortical plates; (b) The target drill depth is dialed in at 9 mm; (c) Access to the operative site was gained through an envelope incision accompanied by a short distal release. The bur was sunk to the planned depth while held at roughly 25°; (d) Sectioning was completed. (e) The initial panoramic image of the impacted lower third molar sitting adjacent to the inferior alveolar canal, and (f) the post-surgical radiograph confirming total clearance of enamel, displaying a smooth, flat cut made 4 mm apical to the alveolar crest.

Close to forty years have passed since the initial coronectomy protocol was put forward as a strategy to lessen the danger of nerve damage when mandibular third molars are situated adjacent to the mandibular canal [4]. In the decades that followed, a body of research and systematic appraisals has affirmed that this modality is a safer option than full extraction for third molars judged to carry a heightened IAN injury potential [6, 9-11]. Nonetheless, the procedure did not turn out to be free of drawbacks, as several publications have cataloged operative sequelae, including early- or delayed-onset infection, unfavorable root shifting, surface exposure, aggravation of the penetrated oral soft tissue, and, occasionally, nerve trauma [14-18]. A scrutiny of these records makes plain that coronectomy needs improvement to curb failure rates. The soundest avenue toward such refinement ought to confront the predisposing factors for the reported untoward events, and perhaps more importantly, the technique must be systematized so that it delivers reproducible outcomes irrespective of the operating surgeon's identity. Our objective in the current work was to bring uniformity to the pivotal step of coronectomy—namely, the transection of the tooth. Executed adeptly, this phase can reduce both outright failure and other attendant morbidities. We explored the optimal bur angulation and penetration distance using a large cohort spanning both sexes. The data disclosed extremely tight intervals of discrepancy between male and female subjects concerning the ideal bur penetration. Such minimal variation supports advocating a unisex average depth of approximately 9.5 mm. This measure was tied to a predefined cutting inclination designed to place the retained root segment at the desired level beneath the alveolar crest. The angle that reliably delivered the intended cut was 25°. The conjunction of the specified penetration distance and bur tilt will preclude the persistence of leftover enamel, a phenomenon

sometimes called enamel lipping. Retained enamel remnants have been correlated with elevated infection rates and procedural breakdown, compelling either the retrieval of the root stump or, at a minimum, a second intervention to shave down the residual enamel ledge [19, 20].

Attaining sufficient depth can diminish instances of under-drilling before crown elevation is attempted, a scenario liable to trigger root segment mobility, which then obliges fragment retrieval, constituting defeat of the planned coronectomy and a compounded nerve injury hazard [20]. By the same token, it can avert over-penetration that risks breaching the lingual cortical plate of the mandible, with ensuing soft tissue tearing or, more uncommonly, possible insult to the main lingual nerve trunk. Pogrel *et al*. [21] and Pogrel [22] authored two comprehensive articles that delineate the coronectomy method for broad clinical use. Their recommendation involved reflecting a lingual flap and employing a dedicated retractor to shield the nerve by holding the lingual soft tissues aside. Yet it is broadly acknowledged, and was substantiated in a recent systematic review with meta-analysis, that this maneuver tends to raise the incidence of lingual nerve disturbance, which is mercifully characterized in most instances by transient tongue paresthesia [2]. For this reason, we endorse a uniform depth and inclination that permits the surgeon to cease drilling while roughly 1 mm of dentin remains, thus sidestepping these unwanted outcomes. The intact 1-mm dentinal bridge is expected to separate cleanly without imparting micromovement to the root remnants. Our observations indicate that a 2.7-unit increase in bur angle requires roughly a 1-unit increase in bur depth. This relationship raises concerns about the use of a considerably steeper angle—45 degrees, for instance —as proposed by Pogrel *et al*. [21]. Specifically, adopting such an approach could substantially deepen the transection, leaving a thick residual dentin shelf on the lingual surface of the tooth. This, in turn, renders the crown segment's disconnection more technically demanding and increases the risk of root fragment mobilization or even the forceful ejection of the root body during the cutting phase. Furthermore, the treating clinician must thoroughly appraise the tooth's buccolingual lean. For teeth with a more pronounced buccolingual tilt, the bur's penetration depth should be reduced to account for that inclination.

Conclusion

Coronectomy constitutes a viable treatment avenue for diminishing the odds of inferior alveolar nerve compromise in cases assessed as moderate or high risk. That said, certain inherent hazards accompany the technique, among them intraoperative impediments, outright failure, post-surgical infectious complications, root re-emergence, and the need for additional operative procedures. The authors are mindful of the study's shortcomings and anticipate clinical trials to corroborate the proposed protocol's results. Nevertheless, the careful dissection of cutting angulation and depth in combination, as outlined in this report, may assist operators in better appreciating how these parameters sway surgical success. Adhering to a uniform technique can promote reproducibility and improve outcomes, even when the procedure is performed by practitioners with disparate levels of surgical experience.

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Conflict of Interest: None

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Ethics Statement: The studies involving humans were approved by the Research Ethics Committee at the University of Sharjah. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from participants or their legal guardians/next of kin, in accordance with national legislation and institutional requirements.

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