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SMART-Section: A Radiographic Sectioning Decision Algorithm for Surgical Removal of Impacted Mandibular Third Molars

Dr. Roopesh U[1], Dr. Arjun Madhu Usha[2], Dr. M. Devanarayanan Potti[3], Dr. Sreesha S[4], Dr. Anjali Anandan Unnithan[5], Dr. Ajimsha S.B[6]
Department of Oral and Maxillofacial Surgery, Azeezia College of Dental Sciences, Kollam, Kerala, India
Corresponding author: Dr. M. Devanarayanan Potti

ABSTRACT
Background: *Surgical removal of impacted mandibular third molars often requires osteotomy and tooth sectioning to overcome retention while limiting unnecessary bone removal. Existing systems such as Winter's and Pell and Gregory's classifications describe tooth position and depth, but they do not prescribe a standardized sectioning strategy. Radiographic predictors of difficulty are useful for planning, although individual indices have limitations in reliability.*
Technical Note: *This article proposes SMART-Section, a radiographic decision-making framework that links preoperative morphology to a planned sectioning and fragment-removal pathway. The algorithm integrates Winter angulation, Pell and Gregory depth and ramus relationship, root morphology, and radiographic assessment of the inferior alveolar canal. Four angulation-directed pathways are illustrated: MA—mesioangular; VI—vertical impaction; HI—horizontal impaction; and DA—distoangular. The supplied SMART-Section schematic is incorporated as the principal algorithm figure, and three complementary flowcharts describe preoperative assessment, angulation-directed selection, and intraoperative reassessment.*
Conclusion: *SMART-Section is intended as a conceptual technical note and educational planning tool rather than a validated clinical scoring system. Its principal value is to make the relationship between radiographic anatomy, sectioning, and the desired path of fragment removal explicit. Prospective studies are required to test whether this framework reduces operative time, unnecessary bone removal, or complications compared with conventional surgeon-directed sectioning.*
Keywords: *impacted mandibular third molar; tooth sectioning; SMART-Section; surgical algorithm; Winter classification; Pell and Gregory classification; inferior alveolar nerve; oral and maxillofacial surgery.*

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I. INTRODUCTION

Impacted mandibular third molar surgery is one of the most frequently performed dentoalveolar procedures in oral and maxillofacial surgery. Although the operation is generally predictable, difficulty increases when the tooth is deeply positioned, has limited retromolar space, unfavourable root morphology, or lies close to the inferior alveolar canal. Surgical difficulty is also influenced by patient and operator factors, meaning that a radiographic classification alone cannot completely predict the operative course.[1]

Winter's classification remains a practical method for describing the angulation of a mandibular third molar, while the Pell and Gregory system describes depth and the relationship of the tooth to the mandibular ramus.[2] These classifications are useful for communication and planning, but studies have shown variable reproducibility and limited ability of traditional indices to predict actual operative difficulty.[3–5] A recent prospective study similarly found that retromolar space and Pell and Gregory position were strongly associated with surgical difficulty, whereas not every conventional variable had the same predictive value.[6]

Tooth sectioning is a central component of controlled third molar surgery. Rather than attempting to remove an impacted tooth as a single unit against a fixed bony or dental lock, sectioning can convert one mechanically unfavourable object into smaller components that can be mobilized independently. Technical guidance has emphasized adequate access, conservative ostectomy, sectioning to decrease retention zones, and movement of fragments along the natural path of withdrawal.[7]

The practical problem addressed by SMART-Section is therefore not whether a tooth should be sectioned, but how the radiographic anatomy can be translated into a planned sectioning and fragment-removal strategy. The proposed framework links the direction of impaction and the main mechanical obstruction to the anticipated direction of fragment removal. It is deliberately simple so that it can be used during preoperative planning, case discussion, postgraduate teaching, and intraoperative reassessment.

II. RATIONALE FOR A RADIOGRAPHIC SECTIONING ALGORITHM

The principal limitation of conventional difficulty assessment is that classification and treatment planning are often separated. A radiograph may be labelled as mesioangular, vertical, horizontal, or distoangular, yet the label itself does not state where a section should be made or which fragment should be removed first. The surgeon must still convert the image into a mechanical plan. SMART-Section places this conversion at the centre of preoperative planning.

Traditional difficulty scores also should not be interpreted as absolute predictors. A meta-analysis found that the Pederson index had low sensitivity and specificity for predicting surgical difficulty, while other studies have demonstrated that difficulty is multifactorial.[4,5,8] Yuasa and colleagues proposed a difficulty classification incorporating depth, available space, and root width, illustrating the importance of morphology beyond simple angulation.[9] Similarly, studies of operative time have identified age, depth, bone impaction, root formation, and proximity to the inferior alveolar canal as relevant variables.[10]

SMART-Section therefore does not replace established classifications. Instead, it uses them as inputs. The algorithm begins with the familiar radiographic description and then asks a second question: what is the most restrictive mechanical feature, and what sectioning pattern creates the safest path for fragment removal?

III. SMART-SECTION: CORE CONCEPT

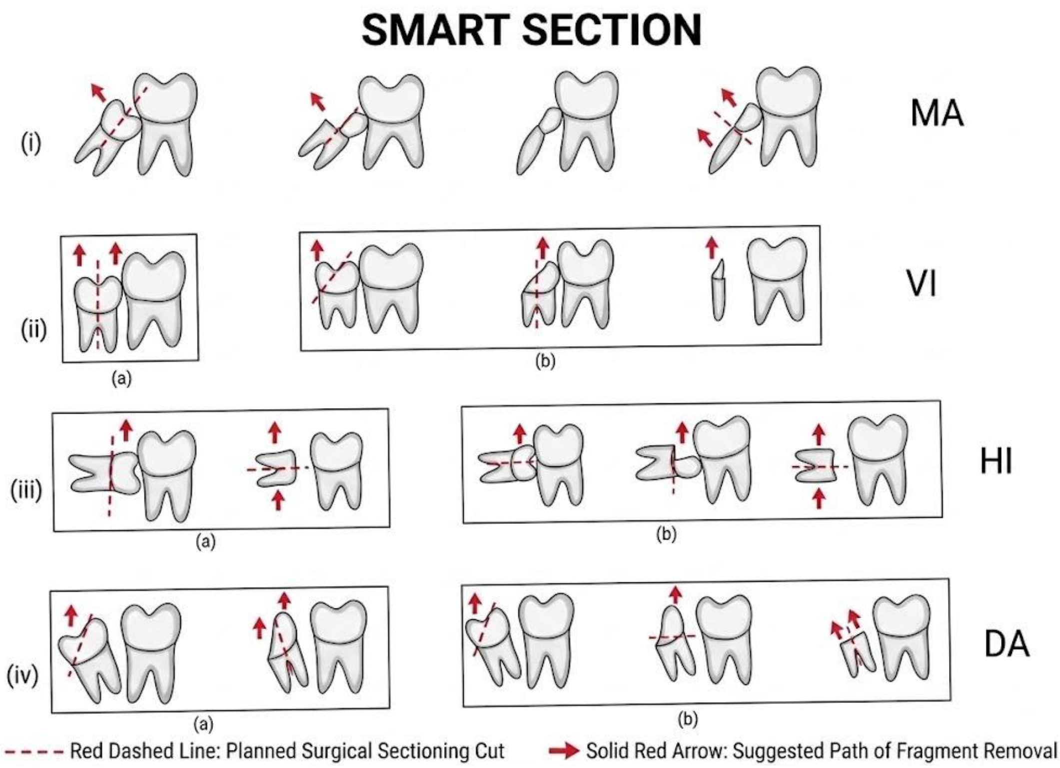

Figure 1. *SMART-Section schematic showing proposed sectioning patterns for four major mandibular third-molar angulations.*

Abbreviations: MA, mesioangular; VI, vertical impaction; HI, horizontal impaction; DA, distoangular. Red dashed line = planned surgical sectioning cut; solid red arrow = suggested path of fragment removal.

The schematic is intentionally presented as a decision framework rather than a rigid operative recipe. The red dashed line represents the proposed plane of sectioning, while the red arrow represents the intended path of fragment removal. The same principle is maintained throughout: section only when it creates a meaningful reduction in retention or improves the path of withdrawal.

The four principal categories are defined as follows: MA—mesioangular impaction; VI—vertical impaction; HI—horizontal impaction; and DA—distoangular impaction. These categories correspond to the common Winter angulation groups used in third molar assessment.[2,11]

IV. PREOPERATIVE RADIOGRAPHIC ASSESSMENT

Panoramic radiography is usually the first-line imaging modality for assessment of an impacted mandibular third molar. The surgeon should record the tooth angulation, depth, retromolar space, root configuration, surrounding bone, and relationship to the inferior alveolar canal. The Winter and Pell and Gregory systems provide a standardized vocabulary for this assessment.[2,11]

The inferior alveolar canal relationship deserves separate attention because radiographic signs such as root darkening or diversion, interruption of the canal's cortical outline, or canal deviation may indicate a closer anatomical relationship. When conventional radiographs suggest intimate contact or when three-dimensional anatomy would materially alter management, cross-sectional imaging can be considered selectively rather than routinely.[12]

Root morphology should be assessed for number, separation, curvature, bulbosity, divergence, and the possibility of root fusion. A sectioning plan should anticipate whether the roots are likely to separate after crown removal or whether an additional root-level division may be required. The presence of an unfavourable root form is associated with greater operative difficulty.[10]

Clinical factors should be incorporated alongside radiographic findings. Mouth opening, cheek and tongue interference, access, patient age, and surgeon experience may affect the practical difficulty of the procedure.[10,13] Consequently, SMART-Section should be regarded as an adjunct to—not a substitute for—clinical judgment.

Flowchart 1. SMART-Section preoperative decision pathway

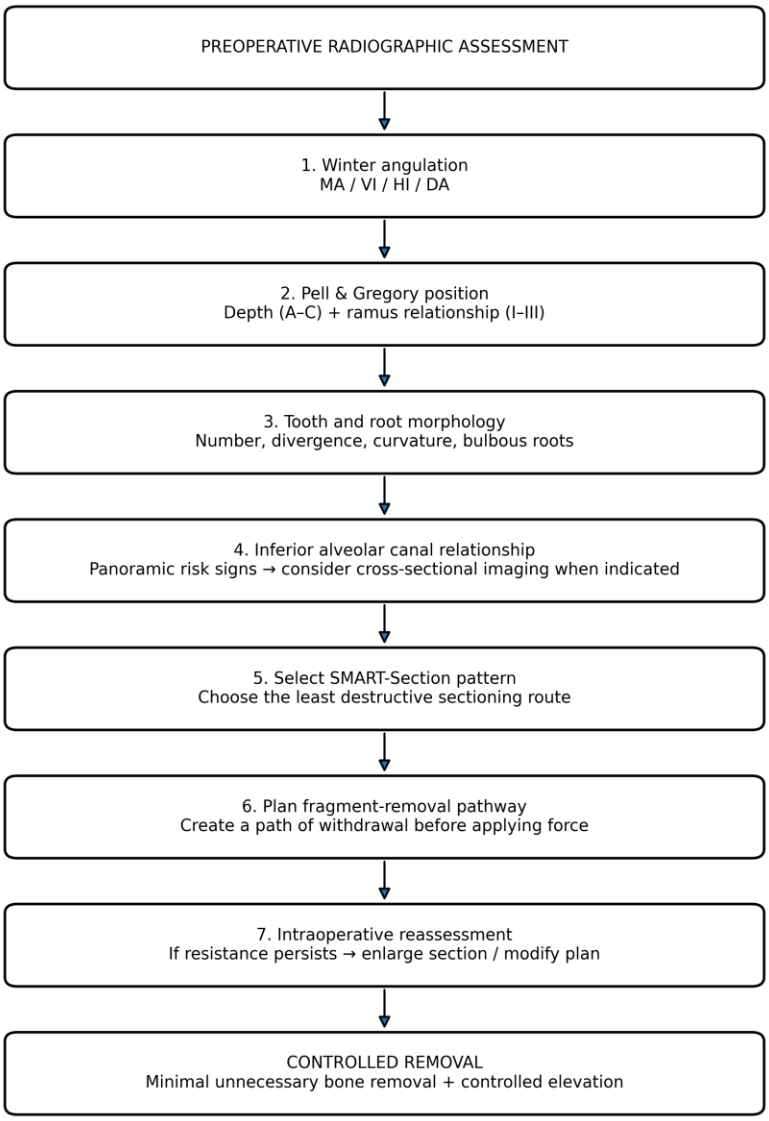

Figure 2. SMART-Section preoperative radiographic decision pathway.

V. STEPWISE SMART-SECTION ALGORITHM

Step 1 — Identify the dominant angulation: Classify the third molar as MA, VI, HI, or DA. This establishes the initial sectioning pathway.
Step 2 — Determine depth and ramus relationship: Record Pell and Gregory level and class. Deep impaction or limited retromolar space should lower the threshold for planned sectioning.
Step 3 — Assess the main mechanical lock: Identify whether resistance is primarily related to the adjacent second molar, distal ramus, depth of bone, root configuration, or a combination of factors.
Step 4 — Assess root morphology: Determine whether the roots are separate, fused, divergent, curved, bulbous, or otherwise likely to resist withdrawal.
Step 5 — Evaluate the inferior alveolar canal relationship: Look for radiographic warning signs and consider additional imaging when clinically indicated. The objective is risk recognition, not automatic avoidance of surgery.
Step 6 — Select the least destructive sectioning pattern: Choose the sectioning plane that reduces the principal retention point and creates a predictable path of fragment removal.
Step 7 — Define the fragment-removal sequence: Plan which component is to be removed first and in which direction. Fragment mobility should be created before forceful elevation.
Step 8 — Reassess intraoperatively: If the planned movement is not obtained, reassess the locking point and modify the sectioning rather than simply increasing elevation force.

FLOWCHART 2. ANGULATION-DIRECTED SMART-SECTION SELECTION

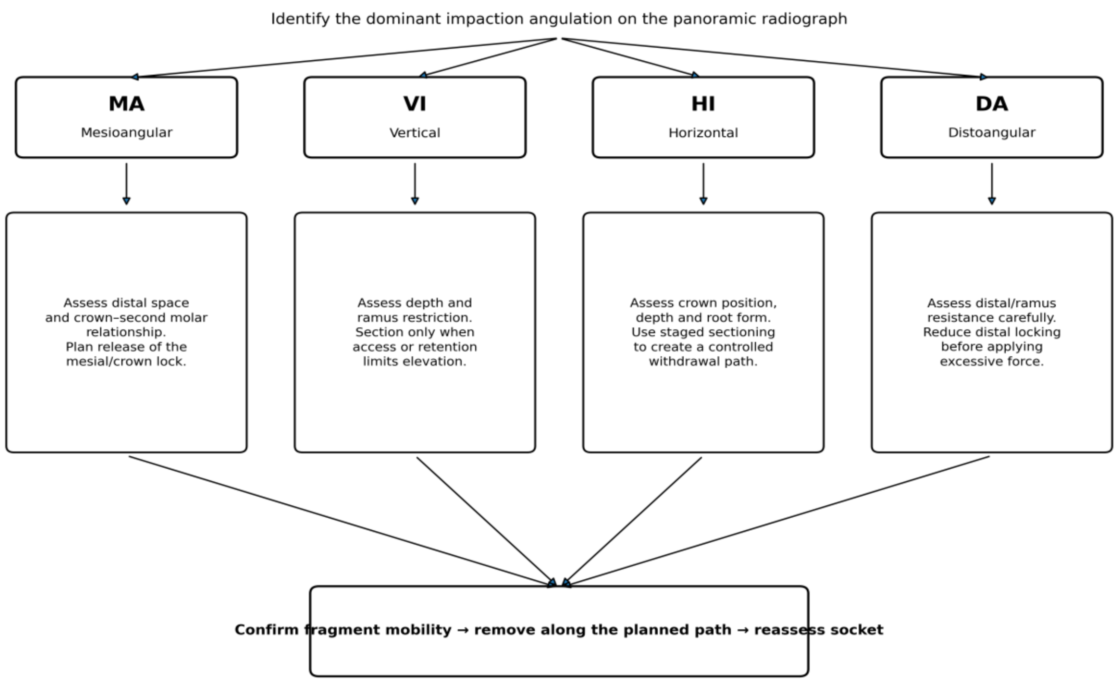

Figure 3. *Angulation-directed selection pathway. The exact sectioning plane should be individualized to the three-dimensional anatomy and the dominant retention point.*

VI. ANGULATION-SPECIFIC APPLICATION

6.1 Mesioangular (MA)

Mesioangular impactions are commonly encountered and may present a mesial crown lock against the distal aspect of the mandibular second molar. The SMART-Section approach is to identify the mesial retention point and select a section that releases the crown or another obstructing component without unnecessary removal of surrounding bone. The planned fragment should then be mobilized along the path indicated by the schematic. When the roots remain mechanically locked after crown removal, a separate root-management strategy may be required.

6.2 Vertical impaction (VI)

A vertically positioned third molar may appear favourable on panoramic imaging but can remain difficult when deeply placed or enclosed by bone. In this situation, sectioning is considered when elevation is constrained by depth, limited access, or the adjacent tooth. The objective is not to section routinely, but to create sufficient mobility and a controlled path of withdrawal.

6.3 Horizontal impaction (HI)
Horizontal impactions often require careful planning because the long axis of the tooth is directed toward the second molar and the tooth may be deeply embedded. A staged approach can separate retained components and permit removal along the least resistant pathway. Excessive force against the adjacent tooth or lingual cortex should be avoided.

6.4 Distoangular impaction (DA)
Distoangular impactions may present a posteriorly directed path with substantial ramus-related resistance. The SMART-Section principle is to reduce the distal locking effect before applying force. The planned cut should therefore be chosen to facilitate controlled movement rather than forcing the whole tooth through a restricted posterior pathway.

VII. FRAGMENT REMOVAL: THE PATH-OF-WITHDRAWAL PRINCIPLE

Tooth sectioning is only useful when the resulting fragment can be removed predictably. A section that creates a free fragment but leaves it trapped in the same bony or dental undercut does not solve the mechanical problem. SMART-Section therefore treats the removal pathway as part of the sectioning decision rather than as a separate step.

Before making the cut, the operator should mentally trace the intended movement of each component. The fragment should be directed into the area of least resistance. Elevation should be controlled and should follow the curvature and orientation of the roots rather than being driven by excessive apical or distal force. This approach is consistent with technical recommendations emphasizing sectioning to reduce retention zones and dislocation along a planned path of withdrawal.[7]

When fragment movement is not achieved after the planned cut, the correct response is reassessment. The operator should identify the remaining point of locking—whether dental, bony, or root-related—and modify the section or perform limited additional ostectomy as required. Blind escalation of force can increase the risk of root displacement, cortical fracture, damage to the adjacent second molar, or neurological injury.

Flowchart 3. Intraoperative safety loop

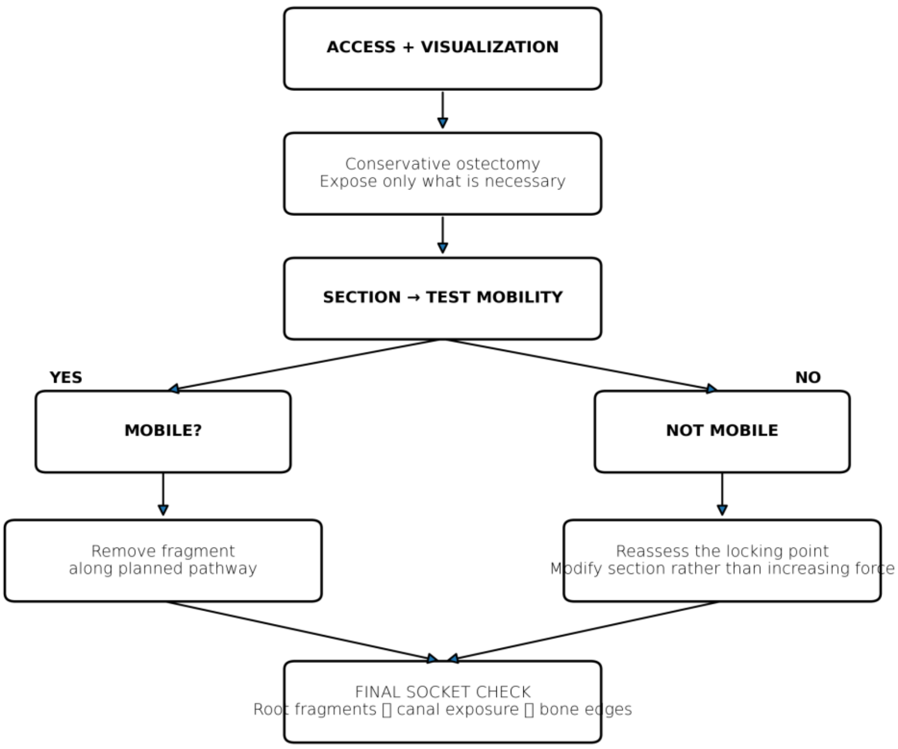

Figure 4. Intraoperative safety loop emphasizing reassessment rather than force escalation.

VIII. SURGICAL SAFETY CONSIDERATIONS

Conservative bone removal remains an important principle of third molar surgery. The purpose of sectioning is to reduce the amount of bone that must be removed and to permit controlled delivery of the tooth. However, the amount and location of ostectomy must be individualized to the tooth position and access required.[7]

Neurological risk should be considered before surgery and throughout the operation. The inferior alveolar nerve may be closely related to the roots, and the lingual nerve is vulnerable to operative manipulation in the lingual region. Technical recommendations include appropriate flap access, conservative distal and distolingual ostectomy, controlled tooth sectioning, and avoidance of excessive dislocation.[7]

Radiographic proximity to the inferior alveolar canal is an important risk marker. Where the tooth is in intimate relationship with the canal, the treatment plan may include alternative strategies such as coronectomy in appropriately selected cases. Systematic reviews have reported lower rates of inferior alveolar nerve disturbance with coronectomy compared with complete extraction in high-risk teeth, although patient selection and long-term follow-up remain important.[14,15] SMART-Section is not intended to determine whether coronectomy is indicated; it is a sectioning-planning framework for cases in which surgical removal is being undertaken.

Mandibular fracture is uncommon but potentially serious. Deep impaction, limited bony support, and difficult third molar position are recognized risk factors. Excessive force should therefore be avoided, particularly when the tooth has not been adequately mobilized.[16]

IX. PRACTICAL SMART-SECTION CHECKLIST

Domain	Radiographic question	Planning implication
Angulation	MA / VI / HI / DA?	Select initial sectioning pathway
Depth	Pell & Gregory A / B / C	Estimate access and bone resistance
Ramus relationship	Class I / II / III	Assess posterior space and delivery route
Second molar	Is there a crown lock or root proximity?	Avoid uncontrolled force against adjacent tooth
Roots	Number, curvature, divergence, bulbosity?	Anticipate separate root management
IAN canal	Relationship and warning signs?	Risk stratification; selective additional imaging
Fragment path	Where will each fragment move?	Make the section serve the planned withdrawal path
Intraoperative response	Is the fragment mobile?	If not, reassess the locking point before increasing force

X. EDUCATIONAL AND CLINICAL APPLICATION

SMART-Section can be incorporated into postgraduate teaching as a structured radiographic-to-operative reasoning exercise. The learner can be asked to identify the angulation, depth, ramus relationship, root morphology, and canal relationship, followed by selection of the expected sectioning pattern and fragment-removal pathway. This makes the reasoning behind tooth sectioning explicit rather than teaching sectioning as a collection of isolated technical manoeuvres.

The framework may also support preoperative team communication. A case can be described in a standardized sequence: impaction category, depth, ramus relationship, root morphology, canal relationship, proposed section, and planned fragment-removal direction. Such a sequence may reduce ambiguity during surgical planning and can be incorporated into operative notes or teaching templates.

Recent work on digital and artificial-intelligence-based difficulty assessment suggests increasing interest in automated radiographic prediction of third molar surgical difficulty.[17,18] SMART-Section differs from these systems because it is an interpretable, rule-based framework rather than an image-classification model. Its future development could therefore include validation against operative time, number of sectioning cuts, bone removal, postoperative morbidity, and clinician-rated difficulty.

XI. LIMITATIONS

SMART-Section is a conceptual technical note and has not yet been prospectively validated. The proposed pathways are based on established radiographic and surgical principles but should not be interpreted as evidence that one sectioning pattern is superior for every tooth within an angulation category.

The algorithm also does not assign a numerical score. This is deliberate: traditional difficulty indices have shown variable predictive performance, and a numerical score may create a false impression of precision.[4,5] The framework instead emphasizes the dominant mechanical obstruction and the path of fragment removal.

Panoramic radiography is two-dimensional and cannot completely describe three-dimensional root position, cortical thickness, or canal relationships. In selected cases, additional imaging may alter the operative plan. Finally, surgeon experience, patient anatomy, access, and intraoperative findings can require deviation from the preoperative algorithm.

XII. FUTURE DIRECTIONS

Future studies should test SMART-Section in prospective cohorts of impacted mandibular third molars. A standardized case-record form could capture angulation, Pell and Gregory position, root morphology, canal relationship, sectioning pattern, number of cuts, duration of surgery, amount of ostectomy, postoperative pain and swelling, trismus, alveolar osteitis, nerve disturbance, and other complications.

Inter-rater studies should determine whether surgeons can reproducibly select the same SMART-Section pathway from standardized radiographs. Criterion validity could be explored by comparing the proposed pathway with operative findings and independent measures of difficulty. Randomized or controlled comparative studies could subsequently compare SMART-Section-guided planning with conventional surgeon-directed sectioning.

Integration with digital radiographic measurement and artificial intelligence may eventually permit automated identification of impaction angulation, depth, root morphology, and canal relationship. However, any automated system should preserve interpretability and allow the surgeon to override the suggested plan when clinical or three-dimensional findings indicate otherwise.

XIII. CONCLUSION

SMART-Section provides a simple, radiographically anchored framework for translating mandibular third molar morphology into a planned tooth-sectioning and fragment-removal strategy. By incorporating Winter angulation, Pell and Gregory position, root morphology, and inferior alveolar canal assessment, the framework encourages the surgeon to identify the principal mechanical obstruction before applying force. The proposed MA, VI, HI, and DA pathways are intended for structured planning and education, not as rigid operative rules. Clinical validation is required before the algorithm can be recommended as a validated predictor of surgical outcomes.

DECLARATION

This manuscript is presented as a conceptual technical note. No patient-level clinical dataset or identifiable patient information is reported in the present article. The SMART-Section schematic incorporated in this manuscript represents the proposed authors' framework.

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