Saudi Journal of Medicine and Public Health

https://saudijmph.com/index.php/pub

https://doi.org/10.64483/202522429

A Comprehensive Review of Oral Surgical Techniques for the Extraction of Retained and Fractured Dental Roots: Clinical Indications, Procedural Approaches, and Postoperative Outcomes

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Abstract

Background: Retained and fractured dental roots transform routine exodontia into complex surgical scenarios with elevated risks due to anatomical variability, proximity to vital structures, and limited coronal purchase. A rigorous understanding of root morphology, case selection, and tissue-preserving techniques is essential to optimize outcomes.

Aim: To synthesize clinical indications, contraindications, operative armamentarium, techniques, and complication profiles for the extraction of retained/fractured dental roots, highlighting principles that enhance predictability and patient-centered results.

Methods: Narrative review of anatomical considerations, decision frameworks (indications vs. contraindications), equipment and personnel requirements, preoperative preparation including imaging (2D radiographs, CBCT), operative strategies (closed/open retrieval; periotomes, piezosurgery; endodontic file/needle engagement; vertical extraction systems), and complication mitigation.

Results: Retained roots warrant removal for infection, pain, periodontal breakdown, restorative/implant planning, and associated pathology; however, removal may be deferred when risks to IAN or sinus, extensive bone loss, root submergence objectives, or patient preference outweigh benefits. Team readiness, profound anesthesia, enhanced visualization, and judicious escalation from closed to open techniques reduce morbidity. CBCT improves risk assessment near the sinus and mandibular canal. Minimally invasive tools (periotomes, piezosurgery, vertical systems) can preserve alveolar architecture but require careful case selection.

Conclusion: Safe, efficient retrieval hinges on anatomy-guided planning, imaging-informed risk stratification, tissue-conserving instrumentation, disciplined force control, and coordinated team performance. Referring to a different method when proximity to critical anatomy or technical complexity elevates risk.

Keywords: retained dental roots; fractured root; exodontia; CBCT; periotome; piezosurgery; vertical extraction; inferior alveolar nerve; maxillary sinus; complications.

Introduction

Retained tooth roots represent a frequent clinical sequela of crown–root fracture and are encountered across a wide spectrum of dental and oral surgical settings. Such fractures may arise from advanced dental caries, extensive restorative procedures, endodontic weakening of tooth structure, traumatic injury, or iatrogenic factors related to operative manipulation. Regardless of the precipitating cause, the persistence of root fragments within the alveolus is clinically significant because it can complicate treatment planning, prolong surgical time, and increase the risk of intraoperative and postoperative adverse events. Consequently, retained

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Receive Date: 01 December 2025, Revise Date: 28 December 2025, Accept Date: 31 December 2025

roots should not be regarded as a routine extension of standard exodontia, but rather as a distinct clinical entity that often demands heightened diagnostic vigilance and tailored operative strategies [1][2]. The surgical difficulty associated with retained roots is influenced by multiple anatomical and procedural variables, including the extent of remaining coronal structure, root morphology and curvature, proximity to vital structures, density of surrounding cortical bone, and the presence of ankylosis, hypercementosis, or periapical pathology. These factors collectively determine whether conservative measures are sufficient or whether an escalated surgical approach is warranted. In this context, the extraction of retained roots frequently necessitates specialized techniques and instruments that differ from those used in conventional tooth removal, with an emphasis on controlled access, atraumatic mobilization, and preservation of adjacent hard and soft tissues. Meticulous management is particularly important when future restorative rehabilitation, such as implant placement or prosthodontic reconstruction, is anticipated, as unnecessary bone removal or soft-tissue trauma may compromise subsequent outcomes [1][2]. This article therefore provides an academically grounded overview of the key surgical and non-surgical considerations relevant to the removal of retained tooth roots. It highlights the clinical rationale for appropriate case selection, the operative instruments commonly employed, and the technical principles that support safe and efficient extraction. By synthesizing these elements, the discussion aims to enhance procedural predictability, optimize patient-centered outcomes, and reduce the incidence of complications associated with retained root management [1][2].

Anatomy and Physiology

The dental root constitutes a highly specialized anatomical structure that allows each tooth to function as an integrated biomechanical component of the masticatory apparatus. Through its intimate relationship with the surrounding alveolar bone and periodontal ligament complex, the root provides a stable yet physiologically resilient anchorage capable of accommodating continuous functional loading. This attachment system permits the dissipation and redistribution of occlusal forces generated during mastication, thereby protecting both the tooth and its supporting tissues from localized stress concentration and mechanical failure. In addition to its mechanical role, the root serves as an essential conduit for neurovascular elements, enabling pulpal perfusion and sensory innervation. These neurovascular connections, transmitted through the apical foramen and accessory canals, link the tooth to adjacent vascular networks and neural pathways within the jaws, supporting tissue vitality and facilitating nociceptive and mechanosensory feedback that is fundamental to protective reflexes and normal oral function.[1] For the clinician, an especially important principle is the remarkable degree of anatomical variability that exists in root size, length, number, and curvature across the dentition and among individuals. Such variability directly influences the technical complexity of dental extraction procedures and is a major determinant of whether an extraction proceeds uneventfully or becomes complicated by root fracture, displacement, or iatrogenic injury. For this reason, a rigorous understanding of dental morphology and its common variants is indispensable for safe and predictable exodontia. The developmental origins of the root further illuminate its distinct structural and functional characteristics. Odontogenesis is orchestrated through reciprocal signaling interactions between epithelial and mesenchymal cell populations. Following initiation at the dental lamina, coordinated cellular differentiation drives the sequential deposition of hard tissues that ultimately form the crown and root. Enamel, the most highly mineralized tissue in the human body, is produced by ameloblasts derived from odontogenic epithelium. Dentin, which forms the bulk of the tooth and lies immediately internal to the enamel, is generated by odontoblasts arising from ectomesenchymal derivatives. These processes proceed in a tightly regulated manner such that enamel and dentin apposition collectively establish crown morphology, while also defining the terminal boundary at which crown formation ceases. This transition occurs at the cementoenamel junction, an anatomical landmark demarcating the most cervical extent of enamel and the coronal limit of cementum, thereby establishing the interface between crown and root.

Root development begins only after crown morphogenesis is substantially completed and is governed by a transient but critical epithelial structure known as Hertwig's epithelial root sheath (HERS).[1] HERS functions as a proliferative growth center and morphogenetic guide, shaping the developing root and directing the differentiation of radicular dentin-forming odontoblasts. Its architecture influences not only root length and curvature but also, through complex signaling events, the eventual number of roots and the presence of furcations. The outermost mineralized covering of the root, cementum, is deposited along the radicular surface and serves as the attachment substrate for periodontal ligament fibers that insert into both cementum and alveolar bone. This fibrous attachment permits physiologic mobility while maintaining stability, enabling the tooth to withstand functional loading without ankylosis. Contemporary literature has proposed multiple signaling pathways implicated in regulating root patterning, including mechanisms that appear to influence root number and overall configuration.[1] Nevertheless, despite substantial advances in developmental biology, many of the precise regulatory mechanisms governing root formation—particularly those that explain interindividual variation in humans—remain incompletely characterized and continue to warrant deeper investigation.[1] From a clinical standpoint, the practical relevance of root anatomy lies in its relative predictability within population norms, juxtaposed with frequent and sometimes substantial deviations. Maxillary anterior teeth are commonly described as possessing single roots with relatively straightforward morphology. Maxillary central and lateral incisors typically exhibit single, straight, conical roots, an arrangement that often facilitates routine extraction when adequate coronal structure remains.[2] Maxillary canines also generally present with a single root; however, they are notable for having the longest roots in the dentition, a characteristic that enhances anchorage but can increase extraction difficulty, particularly in the presence of dense cortical bone, root curvature, or ankylotic changes. The length and bulk of the canine root demand careful surgical planning, controlled luxation, and deliberate force application to avoid fracture or damage to adjacent teeth.

In the premolar region, root morphology becomes more variable and clinically consequential. The maxillary first premolar frequently demonstrates a long root trunk that bifurcates into buccal and palatal roots, although a single-root variant may occur.[3] These roots are characteristically slender, and the extended root trunk—often constituting approximately half of the total root length—creates a mechanical predisposition to root tip fracture during extraction.[3] Clinically, this means that even when an extraction appears straightforward, inadequate buccolingual expansion, excessive rotational forces, or insufficient apical luxation can culminate in the separation of one root apex from the remainder of the tooth. Such fractures may necessitate escalation to surgical retrieval techniques that would not otherwise be required. By contrast, the maxillary second premolar is more often single-rooted and less frequently exhibits bifurcation or multiple roots, typically presenting a more uniform root form and, in many cases, a comparatively reduced risk of root separation during extraction. Maxillary molars demonstrate a complex three-root architecture that strongly influences extraction strategy. The maxillary first molar classically has two buccal roots and one larger palatal root.[4] These roots may be divergent, with variable degrees of splay and curvature that can complicate elevation and forceps delivery.[4] A key feature of both the maxillary first and second molars is the tendency toward distal root inclination, with the second molar often exhibiting a more pronounced distal angulation than the first. The maxillary second molar usually retains three roots, yet they are typically less splayed than those of the first molar, a pattern that can sometimes facilitate removal but may also be associated with partial root fusion, particularly on the buccal aspect.[5] Root fusion can reduce the effectiveness of conventional luxation mechanics by limiting the independent movement of individual roots, thereby increasing the need for surgical sectioning or controlled bone removal. Among maxillary molars, the third molar exhibits the greatest anatomic variability of any tooth. Maxillary third molar roots are frequently shorter and more fused than those of the first and second molars, though the degree of fusion and curvature is highly inconsistent.[5] This variability underlies the well-recognized unpredictability of third molar extraction and reinforces the importance of preoperative imaging and cautious intraoperative technique [1][2][3][4][5].

Mandibular root morphology is likewise characterized by general patterns with important exceptions. Mandibular central and lateral incisors typically have single roots, with the central incisor often demonstrating minimal or absent apical curvature.[6] When curvature is present in either mandibular incisor, it commonly inclines distally, a feature that may influence the direction of luxation and the risk of apical fracture if forces are improperly oriented.[6] Mandibular canines generally have single roots; however, they display a clinically notable contrast to their maxillary counterparts in that bifurcated mandibular canine roots can occur, resembling the bifurcation patterns more commonly associated with maxillary first premolars.[6] Although relatively uncommon, this variant has substantial surgical implications because unrecognized bifurcation may predispose to retained root fragments or complicate forceps engagement. In such situations, failure to appreciate the presence of dual canals or bifurcation may lead to incomplete extraction or necessitate additional surgical intervention. Mandibular premolars are most often single-rooted, yet rare bifurcated presentations have been documented. The mandibular first and second premolars frequently exhibit distal inclination of the root tip, and the mandibular second premolar tends to have a longer root than the first.[7] These features, while generally compatible with routine extraction, may influence the optimal direction of luxation and the selection of instruments, especially when coronal structure is compromised or when the tooth is embedded within dense mandibular bone. The mandibular molars typically have two roots—mesial and distal—that are often inclined distally. The mandibular first molar usually demonstrates greater root length and more pronounced splay than the second molar, whereas the mandibular second molar commonly has shorter roots with less divergence. These differences can alter the mechanical behavior of the tooth during luxation and can affect the likelihood of root fracture, particularly if one root is markedly curved or if the furcation anatomy is complex [5][6][7].

Finally, the mandibular third molar presents a unique set of anatomical and clinical considerations. It most commonly possesses two relatively short, often parallel mesial and distal roots with an increased degree of taper compared with the mandibular first and second molars.[8] Yet, as with the maxillary third molar, the mandibular third molar is characterized by substantial morphological variability.[8] This variability may include fused roots, dilacerations, accessory roots, and unpredictable curvature, all of which can complicate extraction and increase the risk of retained fragments. Furthermore, the anatomical context of the mandibular third molar—particularly its proximity to the inferior alveolar canal and the lingual cortical plate—amplifies the clinical importance of accurate morphological assessment. Even when the crown is partially erupted, complex root anatomy may limit the effectiveness of conventional extraction methods and prompt the need for sectioning strategies or staged bone removal to reduce risk to adjacent neurovascular structures. In aggregate, the anatomy and physiology of tooth roots reflect a sophisticated integration of developmental biology, structural engineering, and functional adaptation. The root is not merely an anchoring extension of the crown but a dynamic interface that mediates force transmission, tissue vitality, and sensory feedback through its relationship with the periodontal ligament, cementum, alveolar bone, and neurovascular supply.[1] For the surgeon, the practical implications of root morphology are immediate and consequential. Variations in root number, divergence, curvature, and length can transform an otherwise routine extraction into a technically demanding procedure requiring modified instrumentation, alternative luxation mechanics, or surgical access. Accordingly, a comprehensive morphological understanding—grounded in developmental principles and informed by well-established patterns across the maxillary and mandibular arches—remains fundamental to safe surgical planning, efficient exodontia, and the prevention of complications such as root fracture, displacement, and damage to adjacent structures [5][6][7][8].

Indications

Retained dental roots may warrant removal under a wide range of clinical circumstances, and the decision to proceed is typically guided by a synthesis of patient symptoms, local oral conditions, radiographic findings, and the anticipated requirements of future treatment. In many cases, retained root fragments are not merely incidental findings but represent clinically meaningful foci that may compromise oral health or interfere with planned rehabilitation. Among the most established indications is the presence of acute or chronic infection, including localized periapical pathology, persistent sinus tracts, recurrent swelling, or radiographic evidence of inflammatory change. Retained roots can harbor microbial biofilms and necrotic tissue remnants, functioning as a persistent nidus that undermines host defenses and may contribute to episodic exacerbations.

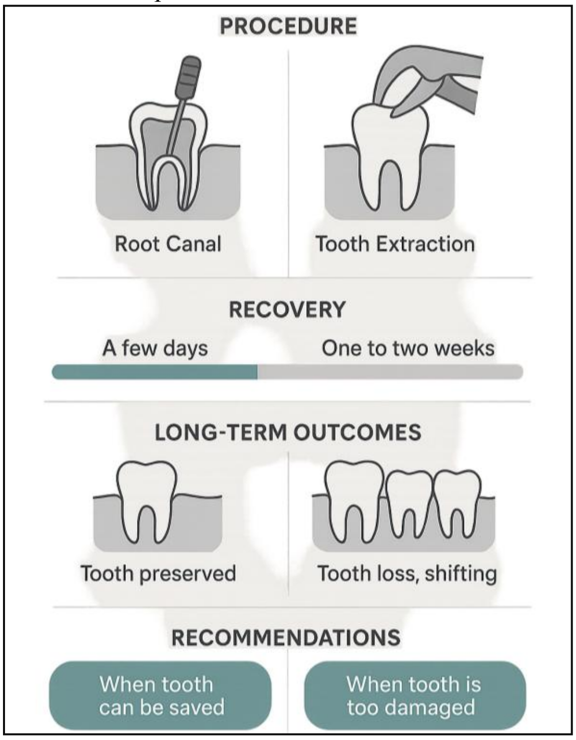

Fig. 1: Tooth root extraction.

Similarly, partial or complete fracture of the crown frequently leaves roots that cannot be predictably restored, particularly when the remaining structure is insufficient for ferrule formation or when restorative margins would be biologically unacceptable. Under these circumstances, extraction of the retained roots becomes essential to eliminate ongoing irritation, prevent progression of caries, and facilitate definitive care. Pain constitutes another major indication, whether arising from pulpal or periapical inflammation, mechanical irritation of surrounding soft tissues, or occlusal trauma affecting compromised teeth. Vertical root fractures represent a particularly important subset because they are often associated with persistent symptoms and refractory inflammation; such fractures are rarely amenable to conservative management and commonly necessitate removal of the fractured root segment to resolve pain and prevent further periodontal breakdown. Periodontal disease is also a frequent driver of root removal, especially when attachment loss, furcation involvement, or mobility renders the tooth non-salvageable or when retained fragments perpetuate periodontal inflammation and pocketing. In addition, extensive caries involving the root surface—particularly subgingival caries that is difficult to isolate or restore—may require extraction when it compromises structural integrity or creates an ongoing risk of infection [7][8][9].

Beyond disease control, retained root fragments may need to be removed to enable future restorative and rehabilitative objectives. Planned dental implant placement is a common indication because residual roots can impede implant osteotomy preparation, reduce available bone volume, and increase the risk of infection at the surgical site. Likewise, the intention to restore the area with a fixed partial denture or removable prosthesis may necessitate removal of retained roots to establish a healthy, stable foundation with appropriate ridge contour and soft-tissue architecture. In this setting, extraction is often performed not only to remove diseased tissue but to optimize the biological and prosthetic environment for long-term function. The presence of associated pathology, such as cystic change, granulomatous lesions, or other radiographically evident abnormalities, further strengthens the indication for removal, as these entities may expand, damage surrounding structures, and complicate future interventions if left untreated. Additional considerations relate to preservation of adjacent teeth and critical anatomical structures. Retained roots may contribute to localized inflammation, compromise periodontal support of neighboring teeth, or create difficulties in maintaining hygiene, thereby indirectly placing adjacent dentition at risk. Esthetic concerns can also be clinically relevant, particularly in the anterior region, where retained roots may be associated with discoloration, gingival contour changes, or chronic low-grade infection that affects soft-tissue appearance. Importantly, the absence of symptoms does not always preclude intervention. Prophylactic removal may be indicated in select asymptomatic patients when future access to dental care is expected to be limited or unavailable, as in individuals anticipating extended deployment or remote placement. Another well-recognized context for prophylactic extraction involves patients preparing for head and neck radiation therapy, where oral infections and non-restorable teeth can become sources of severe complications during or after treatment. Similarly, patients who require medications associated with medication-related osteonecrosis of the jaw may benefit from careful pre-treatment dental optimization to minimize future invasive needs. Across all scenarios, the clinician must balance the benefits of removal against the procedural risks, considering anatomical complexity, systemic factors, and patient preferences. It remains the surgeon's responsibility to communicate the relevant indications, expected outcomes, and potential complications in a manner that supports informed decision-making and valid consent.[9]

Fig. 2: X-Ray of Retained roots.

Contraindications

Although retained root fragments are frequently managed through surgical retrieval, there are clinically important situations in which removal is not advisable because the anticipated benefit does not clearly exceed the procedural risk. In such cases, the clinician's responsibility is to evaluate the biological status of the root segment, the anatomical context, the patient's systemic and local risk profile, and the long-term restorative plan. When these factors indicate that intervention may expose the patient to disproportionate harm, conservative retention of the fragment—either temporarily or indefinitely—may represent the most defensible and patient-centered course of action. Accordingly, retained roots should not be approached with an automatic presumption of extraction; rather, the decision must follow a structured risk–benefit analysis in which the potential for complication is weighed against the clinical necessity of removal. One of the most common contexts for deferring removal is when a retained root is planned to be managed in coordination with future implant therapy. In selected circumstances, maintaining a vital root portion can help preserve the surrounding alveolar bone volume and soft-tissue architecture, which may improve the predictability of subsequent implant placement. This concept is grounded in the biological principle that the periodontal ligament and associated bundle bone are maintained when the root remains, thereby mitigating the ridge resorption that often follows extraction. Consequently, it may be strategically appropriate to leave the retained fragment in situ until the time of definitive implant site development, at which point controlled removal or modification can be performed under conditions optimized for implant surgery. The clinician must, however, remain vigilant for signs of pathology or infection, as the benefits of ridge preservation are contingent upon the retained segment being biologically compatible and clinically stable [8][9].

A major contraindication to removal arises when extraction poses an elevated risk of injury to adjacent teeth or critical neurovascular structures. In the posterior mandible, for example, retained root fragments that are intimately associated with the inferior alveolar nerve (IAN) present a meaningful hazard; aggressive instrumentation may lead to neurapraxia or more significant sensory disturbance.

In such situations, deliberate non-intervention may be preferable, particularly when the fragment is small, immobile, and asymptomatic, and when no radiographic or clinical indicators suggest active disease.[10][11] Similar reasoning applies when the fragment is close to adjacent root surfaces, where attempts at retrieval could precipitate inadvertent damage such as root gouging, luxation injury, or devitalization of neighboring teeth. The principle in these cases is not therapeutic neglect but rather risk containment: avoiding iatrogenic complications that could create greater morbidity than the retained fragment itself. Anatomical proximity to the maxillary sinus and other contiguous spaces also significantly shapes the contraindication profile. Root fragments in the posterior maxilla may be positioned such that attempted removal increases the likelihood of displacement into the maxillary sinus, fracture of supporting alveolar bone, or creation of an oroantral communication. These outcomes can convert a relatively contained problem into one requiring more complex management, including closure procedures, sinus precautions, or referral for advanced intervention.[12] When radiographic assessment suggests that retrieval would require extensive bone removal or would compromise the integrity of the sinus floor, conservative retention may be the safer option, particularly if the fragment is not associated with infection or symptomatic disease. In this setting, clinical judgment must incorporate both immediate surgical risk and the potential downstream consequences of an oroantral defect, including chronic sinusitis, impaired wound healing, and compromised prosthetic rehabilitation [10][11][12].

Prosthodontic considerations can also function as a contraindication, especially when retention of root structure is intentionally used to preserve ridge form. The deliberate maintenance of vital root segments to support the surrounding alveolar bone is commonly described as root submergence, an approach that may be advantageous when future prosthodontic outcomes depend on maintaining optimal soft-tissue contour and ridge volume.[12] In appropriately selected cases, this strategy can improve esthetic and functional predictability by limiting post-extraction collapse, particularly in sites where prosthetic emergence profiles are critical. Likewise, intraoperative root fractures occurring during extraction may not always mandate aggressive retrieval. When a fracture occurs in the setting of a vital pulp, the remaining root segment demonstrates minimal mobilization, and the surgical site can be closed properly without evidence of contamination, it is often reasonable to leave the fragment to heal, provided that careful documentation, patient counseling, and follow-up are ensured. This conservative approach recognizes that additional surgical manipulation may increase morbidity, prolong healing, and raise complication risk without guaranteeing meaningful clinical benefit. Finally, patient preference is an absolute and non-negotiable consideration. Even when clinical indications for removal are present, a competent patient may decline treatment after receiving adequate information about the diagnosis, proposed intervention, alternatives, and potential consequences. Because informed consent is ethically and legally foundational to surgical care, a patient's declination constitutes a definitive contraindication to root extraction.[9] In such instances, the clinician should document the discussion comprehensively, provide clear guidance regarding warning signs that should prompt reassessment, and offer follow-up opportunities to revisit the decision if circumstances change [9][10][11][12].

Equipment

The extraction of retained dental roots relies on an operative armamentarium that largely overlaps with conventional exodontia, yet its successful application typically requires a higher degree of precision, controlled force delivery, and enhanced visualization. Retained roots frequently present with limited coronal structure, altered mechanical purchase, and closer proximity to adjacent teeth or anatomical spaces, which collectively increase the technical demands of the procedure. For these reasons, an appropriately prepared surgical setup should incorporate instruments that support atraumatic soft-tissue management, effective luxation and mobilization, controlled bone modification when required, and reliable hemostasis and wound closure. In practical terms, the clinician must be equipped not only with the standard tools used in routine extraction but also with adjunctive instruments that facilitate predictable retrieval when conventional purchase points are absent or when root morphology and surrounding bone density increase resistance. Core instruments for mobilizing retained root segments include elevators and luxators, which are employed to expand the periodontal ligament space and progressively disengage the root from its alveolar housing through controlled leverage and wedging mechanics. Forceps, while central to routine exodontia, may be of limited utility when the coronal portion is fractured or absent; nevertheless, appropriately selected forceps can remain valuable once sufficient root structure is exposed or when surgical access allows secure engagement. Root tip picks are particularly relevant in retained root management because they are designed to engage small root fragments under direct visualization, especially when fragments are located apically or embedded within granulation tissue. Retractors support safe flap management and soft-tissue protection, allowing improved access and decreasing the likelihood of iatrogenic injury to the lips, cheeks, and mucosa. Curets are used to debride the socket, remove inflammatory tissue, and improve visualization, while dental explorers and mirrors assist with fine tactile assessment and indirect inspection of the surgical field. Scalpels and scissors facilitate precise incision and tissue handling when flap elevation or soft-tissue refinement is necessary, and hemostats provide versatile support for grasping tissue, controlling bleeding, or stabilizing small materials during closure. Periodontal probes are useful for assessing sulcular depth, periodontal attachment status, and socket anatomy, particularly in complex cases where periodontal disease contributes to the indication for extraction [10][11][12].

When surgical retrieval requires modification of surrounding bone or removal of sharp bony edges, rongeurs and bone files become essential for contouring and smoothing the alveolus. A surgical handpiece and an appropriate surgical bur permit controlled ostectomy and root sectioning, which are frequently necessary when retained roots are ankylosed, fractured below the crestal bone, or associated with divergent or curved morphology that resists conventional luxation. The ability to irrigate copiously during bone removal is fundamental; therefore, irrigation needles and syringes, sterile saline, and sterile water should be readily available to cool the surgical site, maintain visibility, and reduce thermal insult to bone. Local anesthetic agents, along with suitable needles and syringes, are indispensable for achieving profound anesthesia and enabling atraumatic tissue management. In addition, sterile gauze supports hemostasis and site protection, while sutures are required for flap repositioning, wound stabilization, and primary closure when indicated. A bite block can assist in maintaining mouth opening, reducing muscle fatigue, and improving operative control during prolonged or technically demanding extractions. Beyond instrumentation, operative conditions strongly influence performance and safety. Optimal lighting is not a minor convenience but a procedural necessity, particularly when retrieving root fragments that may be small, deeply positioned, or obscured by blood or soft tissue. The operatory and the surgical site should therefore be illuminated adequately to allow direct visualization of critical steps, including identification of fracture planes, inspection of socket walls, and confirmation of complete fragment removal. Although not mandatory, magnification is widely used because it enhances visual discrimination and precision in confined surgical fields; many clinicians prefer surgical loupes as part of their routine practice.[13] Similarly, surgical headlamps are frequently employed to deliver coaxial light directly into the operative field, improving visibility and reducing reliance on ambient operatory lighting. These visualization aids can be particularly advantageous during apical fragment retrieval, where minor improvements in visual acuity may substantially reduce unnecessary bone removal and minimize soft-tissue trauma [12][13].

Equally important are infection control and patient protection measures. Every member of the surgical team must wear appropriate personal protective equipment, and the patient should be prepped and draped in a manner consistent with procedural sterility and safety standards. These practices reduce contamination risk, protect mucosal and facial tissues, and support efficient workflow. In recent years, the exodontia armamentarium has expanded to include adjunctive systems designed specifically to facilitate root removal in challenging scenarios. Depending on the clinical approach and operator preference, endodontic files may be used to engage canal spaces, periotomes and specialized luxators may assist in severing periodontal ligament fibers with minimal bone trauma, and vertical extraction systems can provide controlled coronal traction when lateral forces must be minimized.[14] Piezosurgery has also been adopted in some settings because ultrasonic bone cutting can allow selective osteotomy with reduced risk to soft tissues and potentially improved precision in confined spaces.[14] Ultimately, the most appropriate equipment selection is not determined by instrument availability alone but by the anticipated technical challenges of the case and the clinician’s planned extraction strategy. Because retained roots often require nuanced escalation from conservative mobilization to surgical access and retrieval, a comprehensive and well-organized instrument setup is central to procedural predictability. Appropriate instrumentation, combined with enhanced visualization and adherence to operative safety measures, best supports efficient root extraction while minimizing complications and promoting favorable postoperative outcomes, particularly in cases involving retained fragments where routine methods may be insufficient [12][13][14].

Personnel

The personnel required for the extraction of retained dental roots is not uniform across all clinical settings and may vary according to jurisdictional regulations, institutional policies, the complexity of the case, and, most importantly, the level of anesthesia selected. In its simplest and most common outpatient form, the procedure can be completed safely under local anesthesia with a minimal but appropriately trained team. Typically, the essential staffing consists of a single licensed dentist or surgeon who assumes full responsibility for operative planning and execution, supported by at least one surgically trained dental assistant. Within this configuration, efficiency and safety depend less on the number of individuals present and more on the competency, coordination, and role clarity among team members. Under local anesthesia, a well-prepared two-person team is frequently sufficient provided that the assistant is proficient in sterile technique, suction and retraction, instrument handling, and anticipatory support throughout the procedure. During the operation, the surgeon's role encompasses comprehensive preoperative assessment, radiographic interpretation, selection of technique and instrumentation, administration of local anesthesia, and completion of the extraction with appropriate soft-tissue management and wound closure when indicated. The assistant's contribution is simultaneously technical and procedural: maintaining a clear operative field through effective suction, assisting irrigation to improve visualization and reduce thermal and particulate burden, retracting soft tissues to protect the patient and enhance access, and supporting the surgeon through efficient instrument transfer. This anticipatory handoff—whereby instruments are provided at the moment they are required rather than after the surgeon requests them—has meaningful implications for operative flow, procedure duration, and the likelihood of errors arising from distraction or delay. The assistant also supports patient comfort by helping maintain a stable jaw position, placing and adjusting bite blocks, and monitoring for signs of discomfort or anxiety that may necessitate a pause, supplemental anesthesia, or procedural modification. Even under local anesthesia, the assistant plays an important role in recognizing early warning signs of vasovagal episodes, allergic reactions, or unexpected bleeding and ensuring that the surgeon is immediately aware of any change in patient condition [14][15][16].

The staffing needs expand substantially when the procedure is performed with sedation or general anesthesia, as the demands of continuous physiologic monitoring and airway management introduce additional safety-critical responsibilities.[15] In these contexts, personnel requirements are often defined by state or national regulations, professional guidelines, and the credentialing standards of the treating facility. When sedation is employed, team roles typically become more differentiated: while the surgeon continues to perform the operative steps, at least one additional team member may be tasked with continuous monitoring of vital signs and patient responsiveness, as well as documenting intraoperative parameters such as oxygen saturation, heart rate, blood pressure, respiratory rate, and level of sedation.[15][16] The need for role separation is not merely procedural formality; it is rooted in the principle that safe sedation requires uninterrupted vigilance, and that the operator's attention should not be divided between surgical tasks and physiologic surveillance when deeper levels of sedation are used. Responsibilities related to anesthesia monitoring are especially consequential because airway compromise, respiratory depression, and hemodynamic instability represent among the most serious intraoperative risks in outpatient dental settings. An assistant trained in anesthesia monitoring is commonly responsible for constant assessment of airway patency and ventilatory adequacy, early recognition of abnormal trends in vital signs, and immediate communication of any clinically significant change to the operating clinician.[15][16] This role may include ensuring correct placement and function of monitoring equipment, observing chest excursion and breathing patterns, assisting with supplemental oxygen delivery, and being prepared to support airway maneuvers if needed. The degree to which this individual may intervene directly depends on their training, licensure, and the practice setting; however, the essential expectation remains constant: continuous monitoring must be active, not passive, and it must be carried out by someone whose attention is not simultaneously consumed by the surgical field [15][16].

The composition of the anesthesia team itself can vary. Outpatient anesthesia delivery in dental, oral surgery, and oral and maxillofacial surgery clinics generally requires a licensed provider with extensive training in anesthetic administration and perioperative patient management.[16] Depending on jurisdiction and credentialing pathways, the anesthesia provider may be the operating dentist or surgeon—when they are appropriately trained and permitted to provide sedation—or it may be an independent anesthesia professional such as a certified registered nurse anesthetist (CRNA), an anesthesiologist, or a dental anesthesiologist.[16] Each model has implications for workflow and responsibility allocation. When the surgeon is also the anesthesia provider, the clinic must be particularly careful to ensure that dedicated personnel are assigned to monitoring and that emergency preparedness systems are robust. When a separate anesthesia provider is present, the surgeon can focus exclusively on the procedure while the anesthesia professional assumes primary responsibility for sedation titration, physiologic stability, airway management, and recovery criteria. Regardless of model, the key requirement is competence and clear accountability for anesthesia-related decisions and interventions. In addition to the operator, assistant(s), and anesthesia personnel where applicable, ancillary staff play a critical role in ensuring safe, compliant, and efficient care. Administrative and clinical support staff commonly manage essential pre-procedural verification tasks, including confirmation of informed consent, reconciliation of medical history updates and medication lists, documentation of allergies, and verification that indicated radiographs and treatment plans correspond to the intended surgical site.[17][18] These steps may appear routine, yet they function as high-value safeguards against preventable errors, such as wrong-site procedures, overlooked contraindications, or missed medical risk factors. Properly performed intake processes also improve perioperative efficiency by reducing intraoperative interruptions related to incomplete documentation or unverified medical details. Furthermore, staff involvement in patient education—such as postoperative instructions, expectations regarding swelling or pain control, and guidance on follow-up—supports adherence and may reduce unplanned postoperative contact or complications [16][17][18].

Effective team performance depends not only on staffing numbers but on the implementation of structured communication and shared situational awareness. In well-functioning outpatient surgical settings, each team member understands their scope of responsibility, anticipates predictable needs during the procedure, and communicates concerns promptly and unambiguously. This collaborative approach helps establish a culture of safety in which potential errors are intercepted early, emergent events are managed with coordinated efficiency, and patient experience is improved through smoother, more confident care delivery.[17][18] In the context of retained root extraction—where unanticipated complications such as fragment displacement, increased bleeding, or difficulty in retrieval can arise—team readiness and adaptability are particularly important. Therefore, staffing should be matched not only to the anesthesia plan but also to the anticipated complexity of the case, ensuring that adequate support is available to maintain patient safety, procedural precision, and high-quality perioperative care.[15][16]

Preparation

Comprehensive preparation is foundational to the safe and predictable management of retained dental roots and should be approached as a structured preoperative process rather than a brief procedural formality. Because retained root extraction can range from a straightforward retrieval to a technically complex surgical intervention, the clinician must begin with a thorough evaluation of the patient and the proposed surgical site. At minimum, this assessment includes a targeted physical examination and an accurate review of the patient's medical history, current diagnoses, and medication profile. A clear understanding of systemic health is essential because it directly influences intraoperative risk, postoperative healing potential, and the selection of appropriate perioperative strategies. By identifying relevant comorbidities—such as cardiovascular disease, bleeding disorders, immunosuppression, or metabolic conditions—the surgeon is better positioned to anticipate complications, implement appropriate modifications to the treatment plan, and reduce the likelihood of adverse events.[14] Equally important, a careful medication history informs decisions regarding local anesthetic selection, hemostasis planning, antibiotic considerations, and postoperative pain control, thereby supporting individualized and medically appropriate care. Preparation must also include a rigorous local evaluation of the oral cavity and the specific extraction site. Intraoral examination provides critical information regarding the condition of the surrounding soft tissues and the periodontal apparatus, including the presence of inflammation, pocketing, gingival recession, or suppuration that may reflect ongoing infection or periodontal instability. The clinician should assess the extent of caries, the integrity of any remaining coronal structure, and the mobility of the root segment, as these factors strongly influence the likelihood of retrieval using conservative techniques versus the need for surgical access. Adjacent teeth must be evaluated for restorability, periodontal support, and proximity to the retained fragment, as their condition can shape both the operative approach and the risk of collateral damage. This local assessment, when integrated with radiographic findings, supports informed decisions regarding instrumentation, flap design where indicated, and the need for adjunctive hemostatic measures.[9] In practical terms, preparation is not merely about confirming the indication for extraction; it is about creating a plan that accounts for the biological and mechanical realities of the site while aligning with the patient's overall risk profile [9][14].

Radiographic assessment is particularly critical in cases involving retained roots, because clinical visualization alone rarely provides sufficient information about fragment position, morphology, and relationship to surrounding anatomical structures. Traditional two-dimensional radiographs remain valuable as an initial diagnostic tool and are often appropriate for establishing the presence of a retained fragment, evaluating gross root form, and identifying obvious pathology. However, the inherent limitation of two-dimensional imaging is its reduced capacity to accurately depict depth, buccolingual position, and spatial proximity to critical structures—factors that can fundamentally alter surgical risk. With the growing availability and clinical adoption of cone-beam computed tomography (CBCT), clinicians can now more precisely evaluate the depth, angulation, curvature, and size of retained root segments, as well as their relationship to high-risk anatomical landmarks such as the maxillary sinus and the inferior alveolar nerve.[14] This three-dimensional detail can be decisive when the anticipated extraction is complex, when the fragment appears close to neurovascular structures, or when the consequences of iatrogenic injury would be significant. Importantly, CBCT is not mandatory for every exodontia case and should be selected judiciously. Its value is greatest when conventional imaging cannot sufficiently characterize the risk profile or when the operative plan may require surgical bone removal, sectioning, or advanced retrieval techniques. In these scenarios, CBCT supports safer decision-making by allowing the surgeon to visualize the precise spatial relationships that govern complication risk, thereby improving planning accuracy and potentially reducing unnecessary tissue trauma.[14] More broadly, preoperative evaluation serves a dual function: it enables the clinician to generate an accurate diagnosis and it clarifies the most appropriate course of treatment, including whether extraction is indicated, whether an alternative conservative approach is reasonable, and whether referral is in the patient's best interest.[14]

Sound clinical judgment remains the unifying principle throughout preparation. The surgeon should base decision-making on empirical evidence, accepted best practices, and an honest appraisal of procedural difficulty. This includes selecting an operative plan that is consistent with the clinician's training, experience, and available armamentarium. A critical, and sometimes underemphasized, component of preparation is determining whether the case should be managed in the current setting or transferred to a provider with greater expertise or resources. Complex retained roots—particularly those associated with high-risk anatomical proximity, severe curvature, significant bone density, or suspected ankylosis—may be better managed by an oral and maxillofacial surgeon or a facility equipped for advanced surgical care.[9] Recognizing the limits of one's clinical capability is not a weakness but a professional obligation, as referral can reduce patient risk, improve outcomes, and ensure that the procedure is completed safely and effectively. Ultimately, meticulous preparation aligns diagnostic accuracy with procedural planning, mitigates preventable complications, and establishes the conditions necessary for high-quality surgical care in retained root management.[9][14]

Technique or Treatment

Following confirmation of informed consent and a brief procedural "time-out" in which the surgical team verifies the patient, site, and intended intervention, local anesthesia is administered and sufficient time is allowed for profound anesthetic effect before instrumentation begins. This initial phase is more than a comfort measure; inadequate anesthesia encourages reactive patient movement, compromises surgical control, and increases the risk of iatrogenic trauma. Once anesthesia is confirmed, the clinician should proceed with a deliberate strategy that prioritizes efficiency while preserving supporting tissues. A substantial body of clinical evidence and contemporary surgical consensus support atraumatic extraction whenever feasible, particularly in sites where ridge preservation, prosthetic rehabilitation, or future implant placement are anticipated. Advances in instruments, biomaterials, and imaging have increased expectations for tissue-conserving technique, and modern practice increasingly emphasizes minimization of unnecessary bone removal and careful management of gingival architecture. Nevertheless, it remains essential to acknowledge a biologic reality that no extraction is truly "atraumatic," because any loss of a tooth or root segment initiates some degree of remodeling and resorption of the alveolar process.[19] Accordingly, the practical goal is not the elimination of trauma but the reduction of avoidable injury through controlled force, refined access, and appropriate escalation of technique. Several approaches have been developed specifically for the removal of retained root segments. The method selected should be individualized to the fragment's size and position, the presence or absence of mobility, surrounding bone density, root morphology, and the proximity of anatomical structures. Broadly, these approaches can be organized into closed surgical retrieval, open surgical retrieval, and a set of adjunctive or alternative methods—including endodontic file engagement, canal friction techniques using a local anesthetic needle, and vertical extraction systems—each with distinct indications, advantages, and limitations [18][19].

The closed surgical technique is typically the initial approach when the retained root is accessible coronally and adequate visualization can be achieved without reflecting a mucoperiosteal flap. The guiding principle is to mobilize and deliver the root segment from the coronal aspect using sequential elevation and luxation while maintaining the integrity of the surrounding soft tissues and minimizing bone removal. In this context, elevators are employed through fundamental mechanical concepts—wheel, lever, and wedge—which are not mutually exclusive but are often applied in combination as the operator adapts to the fragment's response. When an elevator functions as a wheel, the instrument's tip engages a point of purchase on the root, and a controlled rotational arc is generated, converting rotational motion into coronal displacement of the fragment. Cryer-type elevators are commonly effective for this maneuver because their design facilitates engagement and controlled rotation when an appropriate purchase point exists. In contrast, when an elevator is used as a class I lever, a fulcrum is established—often at or near the alveolar crest—allowing the applied force to translate into coronal movement of the root segment. This method requires reliable purchase and stable fulcrum positioning; otherwise, there is a meaningful risk of slippage, inadvertent soft-tissue injury, or force misdirection that could compromise adjacent teeth.[14] If purchase is insufficient, it may be necessary to create a small bony trough adjacent to the fragment with a surgical handpiece or osteotome to establish access and a controlled engagement point.[14] The wedge principle is central to many closed techniques because it gradually expands the socket while severing periodontal ligament fibers. Here, the instrument's working end is oriented parallel to the root surface and advanced apically with steady pressure. As the tip progresses, ligamentous attachments are disrupted, and the alveolar socket walls undergo controlled expansion. A small void then develops between the root and socket walls, increasing the instrument's range of motion and enabling progressive luxation. With continued controlled advancement, the force delivered ultimately exceeds the resistance of the remaining periodontal ligament fibers, permitting coronal displacement of the root segment.[14] In clinical practice, the operator may alternate rapidly between these mechanical principles—rotating when purchase permits, levering when fulcrum stability is reliable, and wedging to expand the socket and deepen luxation—until mobility is achieved. Once the segment is sufficiently loosened, forceps may be used to deliver the fragment, provided that adequate access and secure engagement can be obtained without crushing or further fracturing the root [14].

Several adjunctive maneuvers can enhance closed retrieval while preserving tissues. Root sectioning, when feasible, may transform a resistant fragment into smaller segments that can be removed independently. In some circumstances, a small hole can be drilled into the root to accommodate a crane pick or similar instrument, thereby creating a deliberate purchase point and enabling levering of the fragment coronally.[14] When preservation of gingival margins and alveolar architecture is especially important, a periotome may be advantageous. The periotome's thin, blade-like tip is introduced into the periodontal ligament space and advanced circumferentially to sever ligament fibers while minimizing socket expansion and limiting cortical bone trauma. Manual and powered forms are available, and their utility is particularly evident when the goal is to avoid extensive cortical plate disruption and protect delicate soft-tissue contours.[20] Piezosurgery represents another advancement aligned with tissue-preserving goals. Ultrasonic bone cutting produces osteotomies through microvibrations that can generate cleaner, more controlled cuts than traditional rotating burs or oscillating saws. This precision allows the surgeon to remove only the amount of bone necessary to facilitate retrieval and can be advantageous in confined spaces or near sensitive anatomy. A commonly cited benefit is the reduced tendency to injure soft tissues and neurovascular structures compared with conventional rotary instruments that cut hard and soft tissues indiscriminately.[20] While piezosurgery does not eliminate the need for surgical judgment or skill, it offers a refined method for bone modification when closed techniques alone are insufficient, potentially reducing collateral trauma. In all closed approaches, the clinician's tactile feedback is a primary guide: with experience, surgeons develop a calibrated sense of appropriate force, recognizing when continued elevation is productive versus when escalation risks fracture or displacement and an alternative plan is warranted [20].

When closed methods fail, when visualization is inadequate, or when the fragment is deeply positioned or otherwise inaccessible, an open surgical technique may be required. This approach involves reflecting a mucoperiosteal flap to improve visualization and provide access for controlled bone removal, root sectioning, or both. Flap reflection is often performed as a full-thickness flap, meaning the periosteum is elevated with the overlying mucosa, permitting direct access to underlying cortical bone. The open approach is particularly valuable when the fragment lies below the crestal bone level, when it is ankylosed or surrounded by dense bone, or when repeated attempts at closed retrieval increase the probability of further fracture. Although flap reflection alone is not typically the sole driver of bone loss, it is clinically relevant that a substantial portion of alveolar blood supply is derived from the periosteum; disruption of this vascular contribution may influence postoperative remodeling and the amount of alveolar bone remaining after extraction.[20] For this reason, open techniques should be performed with careful tissue handling, minimal flap trauma, and thoughtful closure to support favorable healing. The introduction of the rotary surgical drill has fundamentally transformed the transition from simple to surgical exodontia, offering efficient access to bony and dental structures that are otherwise difficult to reach with hand instruments alone.[14] When indicated, cortical bone can be removed in a controlled manner to expose the fragment and create space for elevator engagement. Alternatively, roots can be sectioned to facilitate segmental retrieval, reduce resistance, and avoid excessive force on the alveolar walls. In multi-rooted teeth or retained multi-root fragments, a common operative principle is to treat each root as though it were a single-rooted tooth; doing so reduces the need for socket expansion across a broad area and can limit trauma to the supporting alveolus.[21] Maxillary molar roots are frequently sectioned at the furcation in configurations that facilitate independent root removal, often described as Y- or T-shaped patterns depending on the tooth and furcation anatomy.[20] Mandibular molars and other two-rooted teeth are commonly sectioned horizontally through the furcation to separate mesial and distal roots, enabling sequential retrieval with more controlled force vectors.[22] Throughout drilling and sectioning, copious irrigation is essential to dissipate heat, remove debris, and protect bone from thermal injury, with the recognition that surgical efficiency should never supersede tissue safety [20][21][22].

In select circumstances, alternative retrieval methods that exploit the root canal space may reduce the need for bone removal and expand the clinician's options when traditional purchase points are absent. The endodontic file technique involves introducing an endodontic file through a visible canal orifice and advancing it apically until frictional engagement develops within the canal.[23] Once engaged, controlled coronal traction may extrude the retained segment. The effectiveness of this technique depends on the amount of contact between the file and canal walls, because greater contact surface area produces greater friction and therefore greater pullout force.[23] Although the optimal file type and size for this purpose have not been definitively established, evidence suggests that a #25 Hedstrom file can generate substantial pullout forces across different root lengths.[23] Even so, clinical variables such as the extent of periodontal ligament attachment, canal patency, and fragment length strongly influence success; shorter apical segments often offer the highest likelihood of effective engagement and removal. Barbed broaches and larger endodontic reamers (for example, size #40 or #50) have been described as adjuncts, with some reports noting the use of sizes up to #80.[23][24] However, larger instruments may limit apical advancement and thus reduce frictional engagement. Additionally, because significant friction is created, excessive or imprudent rotational force can predispose to instrument separation within the canal, converting a retrieval attempt into a more complex problem that may require further surgical intervention.[25] For this reason, the technique demands careful torque control and an appreciation of when the risk of instrument fracture outweighs potential benefit. A related approach is the local anesthetic needle technique, which relies on frictional retention within the canal rather than file fluting. After adequate luxation has been achieved, a standard 25-gauge local anesthetic needle may be advanced through the canal orifice in an apical direction.[23] If the needle engages the canal walls with sufficient friction, coronal traction can be applied to lift the fragment from the socket. This method is generally most effective for smaller, more apical fragments and is valued for its potential to retrieve retained roots without the concomitant removal of supporting bone. However, its utility is limited by canal anatomy, fragment stability, and the degree of mobility achieved through prior luxation, and it should be applied cautiously to avoid forcing fragments apically or causing canal perforation [22][23][24][25].

Vertical extraction systems represent a more contemporary minimally invasive strategy, designed to extrude teeth or root segments through controlled axial traction rather than lateral luxation. In principle, these systems aim to sever the periodontal ligament and deliver the root coronally while preserving the surrounding alveolar bone and minimizing the need for flap reflection.[26] The technique typically involves placing a pin within the retained root—often engaging within the pulp chamber or canal—followed by attachment of an extraction apparatus that stabilizes against the dental arch.[26] Stabilization is commonly achieved using silicone-based putty or impression material, which helps distribute forces and prevent device slippage. A cable or wire connects the pin to the device, and gradually increasing traction is applied until periodontal ligament fibers are completely severed and the root is extruded from the socket. This approach is most predictably effective for single-rooted teeth and isolated root segments; its efficacy declines in multi-rooted teeth, particularly in the absence of prior endodontic therapy, where canal access and retention may be limited.[26] Among vertical extraction devices, the Benex system is frequently cited in the literature as a commonly used commercial option. Yet notable disadvantages have been reported, including the time-intensive nature of the procedure, the need to counterbalance forces against the dental arch—which may place adjacent teeth and supporting bone at risk of accidental fracture—and the relatively high cost compared with conventional instruments.[25] These limitations can reduce practicality in many outpatient settings. In response, alternative lower-cost adaptations of vertical extraction principles have been described. One such technique involves fixation of a miniplate screw within the radicular canal, with a wire looped beneath the screw head. Coronal extrusion is then achieved using a wire twister and a nearby bony surface, such as palatal bone, as a fulcrum, thereby recreating the axial traction concept without reliance on proprietary devices.[27][28] While innovative, such methods still require careful case selection and meticulous technique to avoid iatrogenic injury, and they should be undertaken only when the clinician has appropriate training and a clear understanding of mechanical risk [26][27][28].

Regardless of the selected method, the concluding steps of the procedure are essential to support healing and reduce postoperative complications. The extraction socket should be irrigated copiously with sterile saline to remove bone chips, tooth debris, and residual granulation tissue, recognizing that retained debris can contribute to postoperative inflammation and infection.[14] If a mucoperiosteal flap has been elevated, wound margins should be re-approximated carefully with tension-free closure to protect the surgical site and promote primary healing.[14] Hemostasis is typically achieved with direct pressure using sterile gauze, often moistened with sterile saline, placed over the site while the patient applies gentle biting pressure. These measures, combined with thoughtful technique selection and controlled intraoperative escalation, allow retained root extraction to be performed with maximal predictability while honoring the modern surgical emphasis on tissue preservation, procedural safety, and patient-centered outcomes.[14][19]

Complications

Even with meticulous preparation and technically sound execution, complications may occur during or after the extraction of retained root segments. Surgical risk is reduced through accurate diagnosis, appropriate imaging, careful technique selection, and controlled force application; however, adverse events remain possible because exodontia inherently involves disruption of mineralized tissues, soft tissues, and vascular structures. Importantly, most complications observed in retained root extraction are not exclusive to root retrieval. They are broadly similar to those encountered in both simple and surgical tooth extraction and should be anticipated as part of routine surgical counseling and perioperative planning. Common complications include postoperative pain, bleeding, infection, fracture of supporting bone or, in rare cases, the jaw itself, and delayed healing responses that may compromise the integrity of the wound.[9] In addition, complications such as osteomyelitis and osteonecrosis—while uncommon—carry substantial morbidity and require early recognition and appropriate management. Alveolar osteitis is another well-known postoperative complication, particularly associated with mandibular extractions, in which premature loss of the blood clot leads to exposed bone, severe pain, and delayed recovery. Extraction-related prosthetic defects may also occur, especially in patients undergoing or planning restorative rehabilitation, where ridge alteration or tissue loss may complicate prosthetic fit or esthetic outcomes. Thermal or chemical burns, often iatrogenic, can develop due to improper instrument handling, excessive heat generation, or inadvertent contact with caustic materials, underscoring the need for disciplined intraoperative control.[9]

Among the most clinically consequential considerations in complication risk is the spatial relationship between root tips and adjacent anatomical landmarks, particularly the maxillary sinus floor and the inferior alveolar nerve (IAN). A rare but highly unfavorable outcome of exodontia is the accidental displacement of teeth or root fragments into neighboring anatomical spaces. When this occurs, retrieval may be complex, morbidity may increase, and referral or advanced surgical intervention is frequently required. Root displacement is typically associated with preventable factors, including inadequate preoperative evaluation, excessive or misdirected force, insufficient visualization, and an inadequately reflected mucoperiosteal flap when surgical access is needed.[29] In retained root cases, these risks may be amplified because fragments can be small, deeply seated, and difficult to grasp, and the temptation to “chase” fragments without improved access can paradoxically increase the likelihood of further displacement or collateral damage. The posterior maxilla deserves particular attention because the roots of maxillary posterior teeth often approximate, contact, or even protrude through the ipsilateral maxillary sinus floor. This anatomical relationship is not merely theoretical; radiographic assessments have demonstrated that maxillary molars can protrude into the maxillary sinus in a substantial proportion of patients. One study reported protrusion through the sinus floor in more than 50% of cases, and identified the mesiobuccal root of the maxillary second molar as exhibiting the greatest depth of sinus protrusion among maxillary posterior roots.[30] Such proximity increases the risk of sinus perforation, oroantral communication, or displacement of fragments into the sinus during extraction, particularly when excessive apical pressure is applied or when the fragment is mobilized without adequate coronal control. Beyond the maxillary sinus, root fragments may be displaced into additional deep fascial spaces, including the submandibular, sublingual, buccal, and pterygomandibular spaces.[31] Displacement into these areas can introduce new risks such as infection spread, swelling with airway implications, and the need for more extensive surgical access to retrieve the fragment [29][30][31].

In rare but dramatic circumstances, posterior maxillary teeth or fragments may be displaced into the infratemporal fossa, a deep anatomical region that may require alternative surgical approaches for retrieval and may be associated with greater morbidity.[32] The act of retrieval itself can contribute to patient burden, because exploration of deep spaces often increases operative time, tissue disruption, and postoperative discomfort. Consequently, best practice emphasizes restraint and judgment at the moment displacement occurs. If the displaced tooth or fragment remains fully visible and can be grasped securely without blind instrumentation, retrieval may be attempted cautiously. If visibility is poor, access is inadequate, or the fragment is not readily retrievable under direct control, immediate referral to an appropriate specialist is the prudent and safer pathway.[29] This approach reduces the risk of driving the fragment deeper, damaging adjacent structures, or creating unnecessary soft-tissue trauma during repeated attempts. Another rare but serious complication is iatrogenic nerve injury, which is most relevant to mandibular posterior extractions, particularly mandibular third molars. In some patients, third molar roots may be in intimate proximity to the mandibular canal housing the IAN, creating a scenario in which surgical manipulation, luxation, or bone removal may result in transient or, less commonly, persistent neurosensory disturbance. The frequency of intimate positioning between mandibular third molar roots and the mandibular canal has been reported to be as high as 7.1% in one study, underscoring that this risk, while not universal, is clinically meaningful.[33] Anatomical variation in canal position further complicates surgical planning. Another study observed that the canal most commonly lies inferior to the third molar apex (77%), but may also course along the lingual side (11.8%) or buccal side (8.9%) of the roots, with a smaller subset of cases (0.7%) demonstrating canal passage between roots.[10] These variations matter because they influence which surgical movements or osteotomy directions carry greater risk and whether additional imaging, modified technique, or even alternative management should be considered. Because complications in retained root extraction can occur rapidly and without warning—sometimes precipitated by a single poorly controlled force application—surgeons must approach every case with a disciplined commitment to risk assessment and methodical escalation. The decision to pursue retrieval should be based on an informed appraisal of the fragment's position, mobility, and proximity to critical anatomy, balanced against the consequences of leaving the fragment in situ. When planning is comprehensive and technique is controlled, most severe outcomes are preventable, and the likelihood of complications can be significantly reduced through adherence to best practices in visualization, instrumentation, and procedural judgment.[29][30][31][32][33]

Clinical Significance

Retained root fragments constitute a routine, clinically meaningful finding within general dental practice and oral surgery, arising both as pre-existing sequelae of prior tooth fracture and as intraoperative complications during extraction. Their prevalence is clinically important not only because retained roots may carry biological consequences—such as persistent inflammation, infection risk, or interference with restorative planning—but also because they represent a technical inflection point in exodontia where a procedure can quickly shift from straightforward to complex. For clinicians who frequently perform extractions, the ability to manage retained roots efficiently is therefore a core competency that protects patient safety, preserves workflow efficiency, and reduces procedural stress. In many real-world settings, a fractured crown or a separated root tip occurs unexpectedly, often in the context of thin roots, extensive caries, endodontically treated teeth, or dense supporting bone. When this occurs, the clinician's response must be immediate and methodical: the situation demands accurate reassessment, escalation of technique when indicated, and disciplined avoidance of forceful "chasing" that may increase risk. The clinical significance of retained roots is amplified by broader trends in dentistry. As contemporary practice evolves, general dentists are increasingly performing dentoalveolar surgery, including surgical extractions, ridge preservation procedures, and pre-prosthetic interventions, at rates that are higher than in many previous eras. This expansion of scope has created a corresponding need for structured, evidence-informed guidance on root retrieval, because retained root management requires skills and decision-making that differ from routine forceps delivery. Extraction is often described by experienced providers as "humbling" precisely because anatomical variability, patient factors, and the unpredictability of fracture can challenge even competent clinicians. Retained roots can prolong operative time, intensify patient anxiety, and heighten provider stress, particularly when the fragment is small, deeply positioned, or located near sensitive anatomical structures. These pressures can tempt hurried decision-making; however, patient-centered care requires the opposite: controlled technique, careful visualization, and timely conversion to surgical access when necessary. From an outcomes perspective, the ability to manage retained roots effectively has direct implications for postoperative morbidity, tissue preservation, and future rehabilitation. Overly aggressive removal can cause unnecessary bone loss, soft-tissue trauma, or damage to adjacent teeth, while inadequate removal in the presence of pathology can perpetuate infection or pain. For these reasons, the exodontist must possess not only the knowledge base to understand available methods but also the technical confidence to apply modern, tissue-conserving techniques appropriately. This includes selecting strategies that minimize collateral trauma, knowing when to escalate from closed to open retrieval, and recognizing when referral is the safest option. Ultimately, retained root management is clinically significant because it sits at the intersection of surgical competence, patient safety, and long-term oral rehabilitation, and it demands that providers remain current with evolving techniques to minimize harm and optimize outcomes.[22]

Enhancing Healthcare Team Outcomes

High-quality outcomes in retained root extraction are not achieved by operator skill alone; they are strongly shaped by the preparedness and coordinated performance of the healthcare team. Because dentoalveolar surgery is conducted in a dynamic environment—often with limited operative field visibility, time constraints, and the possibility of rapid changes in bleeding or tissue response—systematic team-based practices are essential. Before the procedure begins, staff should confirm patient identity, surgical site, and the planned intervention through a standardized verification process. This structured confirmation reduces preventable errors and establishes shared situational awareness among team members. Equally important is ensuring that the required instrumentation, disposable supplies, hemostatic materials, and emergency equipment are organized, functional, and immediately accessible before the first incision or luxation maneuver is attempted. This preparation is not administrative overhead; it is a clinical safety intervention that reduces intraoperative delays, decreases the likelihood of improvisation, and supports decisive action when complications occur. Although tooth extraction is most commonly an ambulatory procedure and rarely constitutes an emergency in terms of indication, emergencies can still arise unexpectedly in outpatient surgical settings. Syncope, allergic reactions, airway concerns during sedation, uncontrolled bleeding, or sinus complications may occur even in otherwise routine cases. Managing these events effectively requires role clarity and practiced coordination, because real-time complication response is inherently a team endeavor.[17][18] When each team member understands their responsibilities—whether focused on suction and retraction, monitoring vital signs, preparing hemostatic agents, or assisting with documentation and communication—the team can respond rapidly and coherently, reducing morbidity and improving patient experience. Time in surgery carries tangible costs. Prolonged procedures increase financial burden, elevate patient and provider anxiety, and may contribute to greater postoperative discomfort due to extended tissue manipulation. One of the most effective ways to reduce surgical time and stress is disciplined preparedness, supported by the assistant's ability to anticipate the operator's needs. In complex retained root retrieval, instrument anticipation is particularly valuable because the procedure often requires rapid transitions between elevators, retractors, irrigation, sectioning instruments, and hemostatic measures. When the assistant can supply the correct instrument at the moment it is needed, procedural flow improves, pauses decrease, and the operator can maintain focus on controlled technique rather than logistics.[18] In parallel, training staff to recognize and manage predictable intraoperative complications—such as increased bleeding, soft-tissue tears, or signs of sinus perforation—can reduce downstream morbidity by enabling immediate mitigation rather than delayed response. While risk can never be eliminated in surgery, the most consequential risks often arise from gaps in preparation rather than unavoidable anatomy. Therefore, the surgeon and team must approach every case with comprehensive readiness, ensuring that protocols, materials, and contingency plans are in place without exception, thereby fostering a culture of safety and efficiency that directly benefits patient outcomes.[17][18]

Conclusion:

Retained and fractured dental roots demand a strategic, anatomy-first approach that balances the biological necessity of removal against procedural risk. Thorough preparation—including medical review, local periodontal assessment, and targeted imaging—clarifies indications, reveals proximity to critical structures, and guides selection of conservative versus surgical tactics. CBCT is particularly valuable when two-dimensional radiographs cannot resolve spatial relationships to the maxillary sinus or inferior alveolar canal. Intraoperatively, profound anesthesia, optimal lighting/magnification, and a well-organized armamentarium enable controlled luxation, socket expansion, and, when needed, precise bone modification. Tissue-preserving options such as periotomes and piezosurgery can minimize cortical trauma; adjunctive canal engagement and vertical extraction systems may facilitate coronal delivery where purchase is limited. Yet these methods are not universally applicable—careful case selection and torque/force discipline are essential to avoid instrument separation, fragment displacement, or collateral injury. Complication avoidance relies on imaging-informed planning near the sinus and IAN, timely conversion from closed to open retrieval when visualization is inadequate, and coordinated team readiness for bleeding, syncope, or airway concerns. When anticipated morbidity exceeds benefit—such as intimate nerve/sinus proximity, ridge-preservation objectives, or informed patient declination—conservative retention or referral is prudent. Ultimately, predictable outcomes arise from disciplined escalation, tissue stewardship, and shared situational awareness across the care team.

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