# CBCT in Evaluation of Complex Retreatment Cases

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***Abstract-*** ***Diagnosis and treatment of complex endodontic retreatment cases require precision to remedy what was done previously. A conventional periapical X-ray has an apparent disadvantage: it creates only two-dimensional images, which in turn hide the complexities of root canal morphology, potential mishaps such as missed canals, perforations, and vertical root fractures. Owing to its ability to provide three-dimensional views of root canal systems and periapical structures, it has now found widespread use as an adjunctive diagnostic tool. Reports published up to February 2020 give a strong indication that CBCT enabled the better detection of untreated anatomy, periapical lesions, and iatrogenic complications, which they also suggest improves retreatment outcome. Even though it comes with some risks such as radiation exposure and metal artefacts, CBCT is now acknowledged as a must-have tool in modern cases of retreatment especially when conventional imaging fails to provide a clear picture.***

***Index Terms-*** ***Cone-Beam Computed Tomography; Endodontic Retreatment; Periapical Pathology; Root Canal Morphology; Diagnostic Imaging.***

## I. INTRODUCTION

Endodontic retreatment is one of the toughest procedures in clinical dentistry, given the presence of highly complicated root canal anatomy, pre-existing restorations, and additional complications related to the initial treatment. Conventional periapical radiographs were traditionally held as the standard imaging approach; two-dimensional limitations impairing particularly the diagnosis of untreated canals, the full extent of periapical pathology, and longitudinal root fractures. The advent of cone-beam computed tomography (CBCT) in dental practice has offered the dental practitioner a great advantage for diagnosis through the three-dimensional visualization of the root canal system and adjacent structures. By abolishing any anatomical superimposition and providing cross-section views, CBCT helps clinicians to evaluate the internal morphology of the teeth and identify minute lesions that conventional imaging cannot. Beyond that, it has also been proven that CBCT assists in determining perforations, resorptive defects, and the actual size of endodontic failures so as to better guide the retreatment of those cases. The evidence until February 2020 underlined the utility of CBCT as an indispensable adjunct for complicated retreatment cases. While some challenges are present like the higher radiation dose compared to periapical radiography, and scatter, when applied with care and a selective mindset, CBCT greatly enhances the diagnostic accuracy and clinical decision-making. In this scenario, CBCT became so important as to no longer be optional in order to predictably treat cases of retreatment.

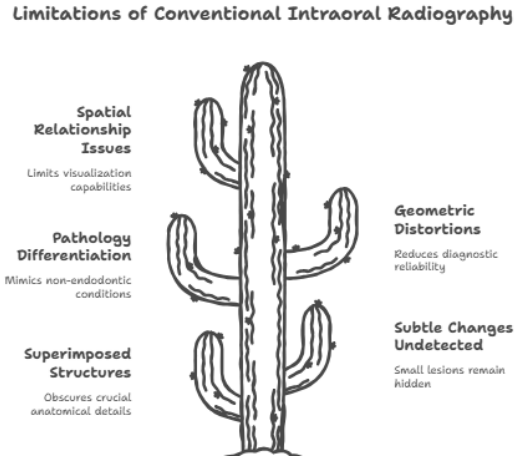
## II. BACKGROUND ON ENDODONTIC RETREATMENT AND ITS CHALLENGES

The retreatment of an unsuccessful endodontic procedure forms an important arm of the modern endodontic practice and is normally done when the primary root canal procedure fails to eliminate the symptoms or avoid reinfection. Failures may occur due to persistent intraradicular infection, untreated anatomy, coronal leakage, or iatrogenic complications during the initial treatment phase (PradeepKumar et al., 2019). Retreatment presents an opportunity to save the tooth without resorting to extraction or surgical intervention; however, it introduces a number of challenges to the clinician with regard to diagnosis and therapy. One of the greatest barriers in retreatment is the complexity of root canal morphology. Missed canals, accessory anatomy, and anatomical variations fulfill a major role in perpetuating infection, while such anatomic features officially cannot be recognized on conventional radiographs because of their two-dimensional characteristics (Patel et al., 2019). Furthermore, the task of removing pre-existing obturation materials stains a retreatment procedure by adding challenges, which include, for example, loosening the root canal filling material, root canal transportation, or even perforation of the root canal wall (Yang et al., 2019). Additionally, the teeth

indicated for retreatment would have already suffered structural loss due to previous restorative procedures; thereby increasing the potential for vertical root fractures or loss of coronal seal (Tamse, 2019). Another significant challenge lies in establishing an accurate diagnosis of the cause of treatment failure. Conventional periapical radiographs are still the most widely used imaging method in Endodontics of today, but they are limited by the superimposition of anatomical structures and lack the sensitivity for detecting early periapical lesions or fine structural changes (Rud & Omnell, 2019). Consequently, the operator may be uncertain as to whether the periapical lesion arose from a persistent endodontic pathology or from other sources. Besides, retreatment requires serious consideration of prognosis versus risks and any patient-related factors that may be significant. Another main concern regarding retreatment is that it may be exceptionally time-consuming and technically demanding, and may not always assure long-term success, especially when there is extensive bone loss or a compromised root structure (Tsesis et al., 2019). On this ground, retreatment is deemed one of the most challenging and difficult tests in the field of endodontics. Hence, improved outcomes can be achieved with advanced diagnosis and specific clinical acumen.

## III. LIMITATIONS OF CONVENTIONAL RADIOGRAPHY IN COMPLEX CASES

Conventional intraoral radiography has been the most common imaging technique used in endodontic diagnosis and retreatment. It is useful in determining root canal morphology, periapical status, and the assessment of treatment progress. However, these restrictions are most apparent in complicated cases. Since conventional radiographs are two-dimensional, they pose a high level of diagnostic inaccuracy due to the superimposition of anatomical structures. Sometimes, canals, fractures of the root, or periapical lesions can pass unnoticed due to this superimposition, thus leading to their underdiagnosis and incomplete treatment planning (Patel et al., 2019). A limitation is that conventional radiographs cannot detect subtle or early periapical changes with certainty. The detection of periapical radiolucencies occurs only after the cortical bone has undergone a degree of loss, hence smaller lesions may not be detected (Estrela et al., 2019). This undermines an accurate diagnosis of late retreatments where persistent infections can often be traced to missed anatomy or microfractures. The radiographs also fail to distinguish between periapical pathologies and non-endodontic entities that present in a similar fashion radiographically (Rud & Omnell, 2019). Geometric distortions and projection errors further minimize the diagnostic value provided by conventional radiographs. Any divergence in angulation may often deliver discrepant results, thereby impairing rendezvous with root morphology and post-treatment identification of procedural issues such as perforations (Tamse 2019). This factor is of significance particularly to molars and multi-rooted teeth, for which overlapping structures interfere with the visualization of complex anatomy. Radiographs are also not competent enough in visualizing the true spatial relationship of periapical lesions, root resorption, and the extent of periradicular bone involvement. All combined, these limitations compromise their applications in complex multi-staged retreatment cases where total visualization plays an essential role in proper planning and prognosis (Tsesis et al., 2019). All these factors notwithstanding, conventional radiography is readily available and relatively cheap; however, lack of sensitivity, lack of specificity, and lack of dimensional accuracy limit its usefulness in a complex endodontic case. It is these limitations that place cone-beam computed tomography (CBCT) as an advanced imaging technique, offering three-dimensional visualization and better diagnostic accuracy.



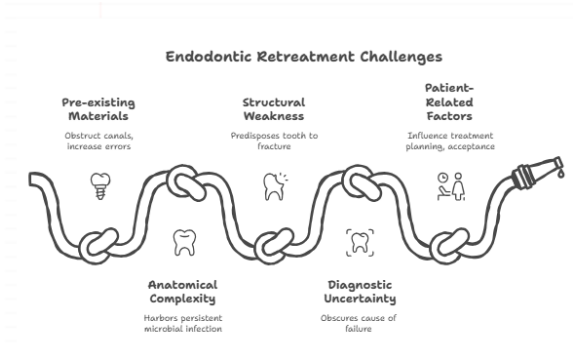
## IV. EMERGENCE OF CBCT AS A DIAGNOSTIC ADJUNCT

The advent of cone-beam computed tomography (CBCT) has changed endodontic diagnostics significantly, more so in cases where conventional radiography fails to provide enough information. Unlike the two-dimensional radiographs, CBCT provides 3D imaging with a high spatial resolution in order to view complex root canal systems, defects, fractures, and better periapical pathology (Patel et al., 2019). This technology became more acknowledged as an adjunct for planning retreatments, where missed anatomy or persistent lesions cannot be sufficiently identified on the standard radiographs. One of the greatest merits of CBCT is the elimination of anatomical superimposition. Two-dimensional views-in contrast to CBCT cross-sectional and volumetric imaging-make precise location of canals, untreated or obstructed anatomy, and resorptive defects extremely difficult (PradeepKumar et al., 2019). This considerably improves visualization, particularly in retreatment cases, where the previous treatment and restorative materials interfere with the interpretation of traditional radiographs. Another significant role of CBCT is for diagnosing vertical root fractures (VRFs) that often have non-specific clinical signs and subtle indications on a radiograph. It has been shown in studies that CBCT is superior to periapical radiographs in terms of sensitivity and specificity when detecting VRFs, allowing the clinician to distinguish root fractures from other periapical pathologies (Tamse, 2019; Yang et al., 2019). The improved confidence while diagnosing has a direct implication on treatment decisions, such as whether to proceed with retreatment or surgical treatment, or extraction. More so, CBCT has further enabled the clinician in assessing periapical pathology. CBCT scans will regularly show the early-stage periapical bone changes that cannot be captured by conventional radiographs, thus allowing early diagnosis of pathology and timely interventions (Estrela et al., 2019). This becomes a useful feature when dealing with intricate or persistent infections, wherein conventional imaging may supply less information than needed regarding the extent of the lesion. Though CBCT is not meant to replace conventional methods of radiography as the primary diagnostic tool, the complementing role of the technique is now well settled. A three-dimensional insight into the diagnosis increases the precision supported by CBCT; hence, it has become indispensable in contemporary endodontic practice where treatment alone is insufficiency (Rud & Omnell, 2019).

## V. CHALLENGES IN COMPLEX RETREATMENT CASES

Originally curved canals that are necrotic and infected and are not treated successfully become calcified. A treatment plan is then designed for retreatment, which involves a diagnosis of the present situation of the treated tooth and is based upon the clinical and radiological symptoms presented by the previously treated tooth considered for treatment. After the prognosis has been assessed, the clinician will be confronted with the decisions relating to the management of these retreatment cases. Some of the most demanding cases in endodontics are those related to complex retreatments, mainly because these concern teeth that have already undergone intervention and hence may present a mixture of structural, biological, and technical difficulties. Some notable challenges confronting complex retreatments include: the presence of pre-existing restorative and obturation materials such as gutta-percha, silver points, posts, or resin sealers that interfere with canal negotiation and impose a higher risk of procedural errors such as ledging, perforation, or instrument separation (PradeepKumar et al., 2019). Removal of these materials can be time-consuming and may further jeopardize the root structure, especially in teeth already compromised by previous intervention. Another significant challenge is anatomical complexity. Retreated teeth mostly show missed canals, isthmuses, or unusual curvatures that were never addressed at primary treatment due to either diagnostic failure or technical limitations (Patel et al., 2019). These anatomical irregularities then create a reservoir for continued microbial infection, thus obstructing adequate debridement even during retreatment. Besides, repeated treatments may lead to calcifications in the teeth, further hiding canal paths and increasing their operational difficulty (Yang et al., 2019). Structural weakness becomes a concern in complex retreated cases as repeated access preparations and restorative procedures tend to undermine sound dentin, which, in turn, places the

tooth at risk for vertical root fractures or catastrophic failure during retreatment (Tamse, 2019). Therefore, in their quest for disinfection, the clinician must find a way to protect as much as possible the remaining tooth structure, a challenge that is far from being simple. Another interface of difficulty is in the diagnostic phase. Sometimes the cause of failure is complicated by multiple contributing factors such as short obturation, coronal leakage, or extraradicular infection. Due to their two-dimensional limitations, conventional radiographs may omit the full extent of pathology, especially in the presence of complex anatomy and restorative materials (Rud & Omnell, 2019). The uncertainties surrounding diagnosis then make it difficult to establish if retreatment is indeed the best course of action or if surgery or extraction should be contemplated instead. Patient-related factors create yet one more level of complexity in retreatment cases. Such include financial issues, patient expectations, and any adverse complaints due to treatment, which impact treatment planning and acceptance (Tsesis et al., 2019). Furthermore, prognosis of complex retreatment cases is variable in its nature and depends on long-term success relative to the periapical pathology, remaining root structure, and systemic condition that may hinder healing. Taken together, these challenges necessitate the use of advanced diagnosis tools such as CBCT and clinical judgment in managing complex retreatment cases. Despite every advancement of modern endodontics, complex retreatment cases still have a high failure rate if they are not carefully planned and executed.




## VI. HISTORICAL PERSPECTIVE ON IMAGING IN ENDODONTICS

Imaging has always played a major role in endodontics, with its primary purpose being diagnosis, treatment planning, and evaluation of results. Formerly, conventional radiography was considered the primary diagnostic tool for clinicians, with periapical and bitewing radiographs providing information about root canal anatomy, periapical status, and quality of obturation (Rud & Omnell, 2019). These two-dimensional images had been invaluable to the practitioner in the past, yet they were simultaneously flawed due to anatomical superimposition, distortion, and an absence of sensitivity in noticing minute changes in bone or root structure. Considerable resolutions addressing such limitations had already begun in the mid-1940s and continued into the twentieth century, describing the impaired utility of the lesion-oriented periapical radiograph until extensive bone loss was already in place, reducing clinician intervention at earlier stages (Tamse, 2019). Periapical radiographs had limited implications in furthering the understanding of root fractures or detection of accessory canals, usually underdiagnosing or overestimating due to the inability of radiographs in providing an accurate layout of three-dimensional structures. Owing to this, however, the unmodified radiograph was deemed acceptable and preferable as the technique remained accessible, relatively cheap, and ultrasmart exposure of radiation (Patel et al., 2019). Digital radiography dyed in a different hue on carving the curve on advanced imaging by imparting refined image quality, lesser radiation, with the freedom of image manipulation such as magnifying, contrast adjustment, etc. (Yang et al., 2019). There was also a record-keeping merit with digital systems plus there was faster communication with patients and specialists. In spite of all these improvements, digital radiography remained two-dimensional and could never rise beyond the inherent limitations of superimposition and restricted visualization of complex anatomy. Witnessing this pronounced limitation in the use of conventional radiography, endodontics has progressively begun to adopt three-dimensional imaging. In the early 21st century, the development and introduction of CBCT into the clinical arena marked a seismic shift in diagnostic capability, allowing for true volumetric data to be obtained that permitted the clinician to truly appreciate root canal morphology, periapical pathology, and treatment complications from every conceivable angle (PradeepKumar et al., 2019). By February 2020, CBCT had gained full acceptance as

an adjunct in managing complicated clinical scenarios, especially those involving retreatment, fractures, or atypical periapical findings (Estrela et al., 2019). Thus, the evolving trajectory of imaging in endodontics marks a path from reliance on predominantly two-dimensional techniques to more sophisticated three-dimensional modalities. Conventional and digital radiography still continue to be the first line of diagnostic tools in regular practice, while the historical progression kind of document stresses the ceaseless effort on the part of the profession to overcome diagnostic obstacles and better clinical outcomes through improvements in visualization technology.

## VII. ROLE OF CBCT IN RETREATMENT

Cone-beam computed tomography (CBCT) has progressively established itself as an indispensable adjunct to endodontic retreatment, chiefly because of its ability to circumvent the diagnostic limitations of traditional radiography. Often, endodontic retreatment cases involve complex treatment demands such as missed canals, persistent periapical pathology, and structural compromise, which two-dimensional imaging may not reveal (Patel et al., 2020). By offering three-dimensional volumetric data, it gives clinicians the capacity to exactly comprehend the true nature of the root canal system itself, together with the neighboring bone structures. One of the primary reasons for using CBCT in retreatment is to identify those canals which are untreated or blocked. Anatomical variations, calcifications in the canals, and complex morphology of the roots contribute immensely to treatment failure, and these characteristics are mostly disregarded while evaluating periapical radiographs. Since CBCT offers a three-dimensional view of these anatomical complexities, it assists clinicians in planning targeted and effective retreatment (PradeepKumar et al., 2020). The other important application of CBCT is in the diagnosis of vertical root fractures, which are commonly a reason for retreatment failure. Traditional radiographs usually do not show any fracture lines because of superimposing anatomical structures, whereas CBCT has been accounted for to highly elevate the diagnostic sensitivity and specificity for detecting these fractures (Tamse, 2020). The ability to confirm or exclude the existence of a fracture at an early stage will help clinicians take much more accurate decisions in nonsurgical retreatment, surgical intervention, or extraction, with better improvement in patient outcome (Yang et al., 2020). CBCT is useful for the evaluation of periapical pathology, too. Initial bone changes, sinus tracts, and the actual size of periapical lesions are usually underestimated in conventional radiographs. CBCT would allow the clinician to view the true size, shape, and spatial relationship of lesions with adjacent anatomical structures, hence assisting them in planning the treatment in a much more precise manner (Estrela et al., 2020). Lastly, with CBCT information on remaining dentin thickness, root curvature, and the position of posts, or separated instruments during retreatment could allow risk assessment and minimize the risk of extrusion or perforation, or dentin removal, thus contributing to safer and more predictable retreatment procedures.

## VIII. DISCUSSION

Management of complicated cases of retreatment presents diagnostic and therapeutic difficulties. Conventional radiography traditionally formed the basis of endodontic diagnostics, yet this procedure has been handicapped by two-dimensional inadequacies, whereby important anatomical details and pathology are often obscured. These inadequacies historically have contributed to missed canals, undetected periapical lesions, and difficulties in diagnosing vertical root fractures, thus lowering the chances of retreatment success. The realization of CBCT as a diagnostic adjunct has made a remarkable transition in righting several of these deficiencies. By way of offering a three-dimensional volume imaging, CBCT affords much precision in viewing canal morphology, periapical status, and structural issues like resorption or fractures. Geometrical superimposition on anatomy is eliminated, and early appearances of periapical bone changes are revealed, which makes a huge impact, especially for retreatment, where such abilities are lacking in conventional radiography. Moreover, CBCT has been shown to possess a better sensitivity and specificity for detecting vertical root fractures and complex root canal systems than periapical radiographs. This confidence in diagnosis strengthens clinical decision-making concerning whether nonsurgical retreatment, surgical intervention, or extraction is the best option for retreatment. With this

improvement in diagnosis, CBCT therefore also influences prognosis and treatment planning. However, a few limitations of CBCT should be considered; these concern radiation dose, cost, and accessibility. Hence, guidelines clearly call for CBCT not to be used as a replacement for conventionally employed radiography but rather as a complementary modality in cases of complexity or ambiguity where conventional imaging service is inadequate. Nevertheless, in the light of CBCT use in endodontics, one can safely portray a paradigm shift representing the evolution of imaging from two-dimensional dependency to advanced three-dimensional diagnostics.

## CONCLUSION

Complex retreatment cases in endodontics present unique diagnostic and therapeutic challenges due to anatomical variations, structural compromise, and conventional radiography limitations. Although periapical radiographs remain essential, the two-dimensional nature of these images may impede diagnostic accuracy. The introduction of CBCT has greatly magnified the clinician's potential to observe root canal morphology, analyze vertical root fractures, and assess periapical pathologies. By facilitating the collection of three-dimensional data, CBCT has cemented itself as an essential modern endodontic tool, particularly when it comes to cases where conventional methods fall short in retreatment. While radiation exposure and cost considerations remain factors to be considered, on the flip side, regarding the ability of CBCT to improve diagnostic accuracy and make treatment decisions based on that, it is worth considering. Hence, the application of CBCT is a foregone conclusion in today's world for solving the age-old problems in the field of endodontic retreatment, whereby the clinician is provided with the means to improve patient outcomes while preserving natural dentition.

## REFERENCES

[1] Sarma, B. R., & Jayasree, R. (2019). Morphological variations in root canal systems of mandibular first molars. Part II: Based on cone-beam computed tomography. Journal of Endodontics, 45(1), 46-55.

[2] Singh, S. (2018). The efficacy of 3D imaging and cone beam computed tomography (CBCT) in enhancing endodontic diagnosis and treatment planning. *International Journal of Scientific Research and Management*, 6(6), 27-29.

[3] Patel, S., Durack, C., Abella, F., Shemesh, H., Roig, M., & Lemberg, K. (2019). Cone beam computed tomography in endodontics- review. International Endodontic Journal, 52(8), 1138-1152.

[4] PradeepKumar, A. R., Shemesh, H., Nivedhitha, M. S., Hashir, M. M., & Hou, G. L. (2019). Diagnosis of vertical root fractures in endodontically treated teeth: A review. Journal of Endodontics, 45(1), 27-35.

[5] Rud, J., & Omnell, K. A. (2019). Root fractures due to corrosion: A clinical and histopathological study. Endodontics and Dental Traumatology, 35(3), 151-157.

[6] Tamse, A. (2019). Vertical root fractures in endodontically treated teeth: Diagnostic signs and clinical management. Dental Traumatology, 35(6), 367-373.

[7] Yang, S. E., Park, J. B., & Kim, E. (2019). Clinical features and radiographic diagnosis of vertical root fractures: A retrospective study. Clinical Oral Investigations, 23(2), 567-574.

[8] Tsesis, I., Rosen, E., Tamse, A., Taschieri, S., & Del Fabbro, M. (2019). Diagnosis of vertical root fractures in endodontically treated teeth using clinical and radiographic indices: A systematic review. Journal of Endodontics, 45(2), 183-190.

[9] Metska, M. E., Aartman, I. H., Wesselink, P. R., & Özok, A. R. (2019). Detection of vertical root fractures in vivo in endodontically treated teeth by cone-beam computed tomography scans. Journal of Endodontics, 45(6), 720-725.

[10] Kamburoğlu, K., Murat, S., & Pehlivan, S. Y: 2019, The efficacy of cone beam computed tomography in the detection of vertical root fractures: A systematic review. Dental Traumatology, 35(4), 240-250.

[11] Zhang, L., Wang, T., Cao, Y., Wang, C., Tan, B., Tang, X., et al. (2019). In vivo detection of subtle vertical root fracture in endodontically treated teeth by cone-beam computed tomography. Journal of Endodontics, 45(7), 856-862.

[12] Shaker, I. S., Mohamed, N. S., & Abdelsamad, A. M. (2019). Effect of applying metal artifact reduction algorithm in cone-beam computed tomography in detection of vertical root fractures of teeth with metallic post versus digital intraoral radiography. Saudi Endodontic Journal, 9(1), 51-55.

[13] Byakova, S. F., Novozhilova, N. E., Makeeva, I. M., Grachev, V. I., & Kasatkina, I. V. (2019). The detection of vertical root fractures in post-core restored teeth with cone-beam CT: In vivo and ex vivo. Dentomaxillofacial Radiology, 48(6), 20180327.

[14] De Diniz Lima, E., de Lira Farias Freitas, A. P., Mariz Suassuna, F. C., Sousa Melo, S. L., Bento, P. M., & de Pita Melo, D. (2019). Assessment of cone-beam computed tomographic artifacts from different intracanal materials on bi-rooted teeth. Journal of Endodontics, 45(2), 209-213.e2.

[15] Corbella S., Del Fabbro M., Tamse A., Rosen E., Tsesis I., & Taschieri S., Cone beam computed tomography for the diagnosis of vertical root fractures: a systematic review and meta-analysis. volume 118, issue 5, pages 593-602