Minimally Invasive Approaches in Endodontic Practice

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This book represents the evolution of my thoughts of the last 18 years of clinical and scientific work, since I was graduated in 2002. I met on my personal journey several people, colleagues and friends who have deeply influenced my life and my way of thinking, both privately and on the working field.

First of all, I want to express a special thanks to my family and the beloved ones, who always support me in everything I do and give me the strength to keep going beyond myself.

I want to thank Nick and Ferr, partners, brotherly friends and indispensable support in my activity.

A special thought to Vinio, Enzo and Gaetano, the people who has more influenced my vision in dentistry and endodontics, helping me to think out of the box and consolidate a lateral thinking and to the teachers that I found during my pre-graduate and post-graduate education: Francesco and Gianluca.

Finally, I am grateful to all my authors and co-authors for their efforts to create such fantastic book!

Gianluca Plotino

Preface

The minimally invasive approach represents a hot topic of the moment in dentistry. Since the technologies, the materials and the techniques are evolving so fast in the dental world, all the disciplines in dentistry advocated for minimal intervention and maximum respect of the healthy natural structures.

"The less is more" concept is a philosophy of living, based on the principles of minimalism and simplicity: very often people confuse "simple" with "simplistic". The objectives of *minimally invasive dentistry* must not have to be misinterpreted by assuming that they are interested only in simplistic procedures. Instead, this philosophy is interested in promoting optimum, minimally invasive treatment for patients in all areas and specialties of dentistry.

"Minimally invasive dentistry" is a philosophy based on evolution of the instruments, materials and techniques, which permits the clinicians to overcome some myths and dogmas deep-rooted in the field and embrace the paradigm shift concept. It represents a fundamental change in the basic concepts and experimental practices of a scientific discipline. Paradigm shifts, which characterize a scientific revolution, arise when the dominant paradigm under which normal science operates is rendered incompatible with new phenomena, facilitating the adoption of a new theory or paradigm.

Minimally invasive concepts easily involved the endodontic world, which is one of the most prone field of dentistry to evolve and overcome old concepts in favour of most actual ones.

In fact, in the last 20 years, endodontists faced a continuous (r)evolution of the field, embracing, very fast, new technologies, materials, instruments, device and concepts in the day-by-day practice. Embracing the concept of minimally invasive endodontics and implementing it in practice represents the perfect example how some paradigms of the field were substituted by new ones based on new phenomena.

The scientific world has now the mission to validate these new concepts and promote evidence-based protocols for clinicians.

The journey that I have tried to trace in the present book aims to give the reader a balanced view on the *minimally invasive* approaches in endodontic practice, describing the most advanced clinical procedures, supported by the most updated scientific data.

I would like to underline here a concept that is very important for me: everything in dentistry, and specially in endodontics, must be based on and guided by the anatomy.

It is the anatomy that dictates every single step of our treatments and procedures embraced to reach a predictable long-lasting clinical result. This is the reason why I would like to conclude this preface stating that the term *minimally* must be seen as a synonymous of *anatomically*, so that I always like to call it: **Anatomically Invasive Endodontics**.

Rome, Italy Gianluca Plotino

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The Role of Modern Technologies for Dentin Preservation in Root Canal Treatment

Carlos Bóveda and Anil Kishen

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1.1 Introduction

Conventional root canal treatment relies on 2-dimension (2D) radiographic images and clinical assessments to comprehend root morphology and root canal anatomy. Despite several technological advances, abiding to typical conventions and/or attempting exploration at the expense of dentin tissue to reveal anatomical variation is still a common practice in root canal treatment (Fig. 1.1). The cause of conventional root canal treatment failure may be attributed to multiple variables. Although conventional practices in root canal treatment display a clinical success of 68–85% [1], among others, missing root canal anatomy, leading to residual intracanal infection [1], and compromised mechanical integrity, leading to fracture [2], have been considered as important causes of endodontic treatment failure.

Bacteria residing in missing canals can contribute to signs and symptoms of failure in endodontically treated teeth [1]. In a study that examined 5616 endodontically treated/retreated maxillary first/second molars, failure to locate

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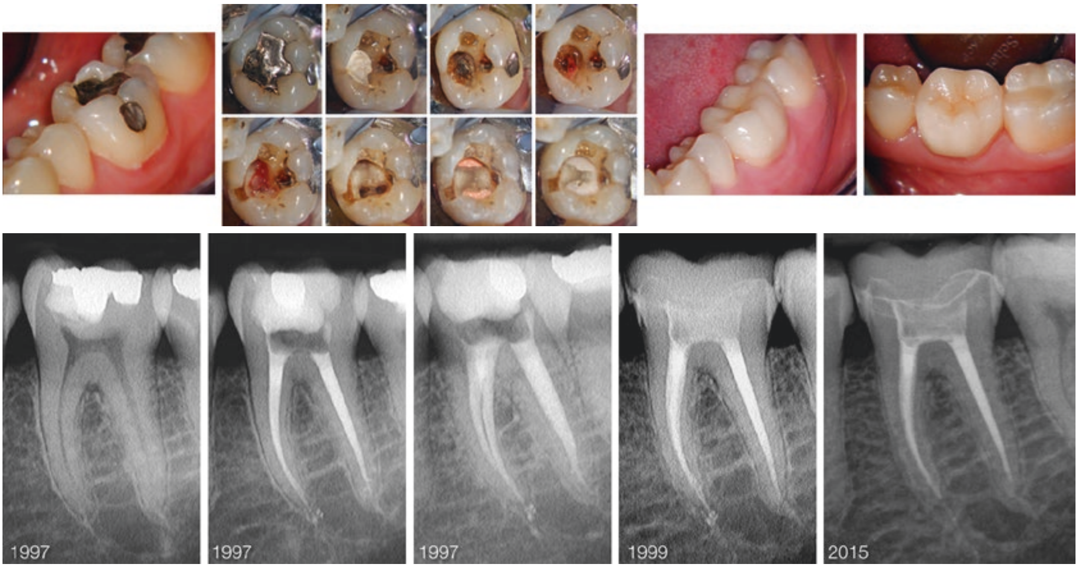

Fig. 1.1 Conventional root canal treatment. This protocol is based on the clinician interpretation of 2D radiographic images with complete unroofing of the pulp chamber space and straight-line access to the roots and canals at radicular level, arbitrary determination of the taper of the preparation as well as clinical inspection for possible anatomical variations detectable with visualization. The restorative procedure for this approach includes a cuspal protective restoration to increase the long-term success. Follow-up on this case is 18 years. Restoration by Dr. Edward De Veer, Caracas, Venezuela

MB2 canal resulted in a significant decrease in the long-term prognosis of endodontic treatment [3]. In another prospective study [4], the incidence of missed canals were reported to be 42% of all the 1100 endodontically failing teeth. Along the same line, it is also suggested that an optimum root canal enlargement coronally and apically is essential for adequate root canal irrigation and subsequent antimicrobial efficacy [5]. Thus, locating all root canals, adequately enlarging the canals, and irrigating the canals with antimicrobial irrigant are major objectives in root canal treatment (Fig. 1.2).

Compromised structural integrity contributes to cracks and fractures in root-filled teeth. Residual dentin thickness plays a key role in teeth survivability after dentin structure loss through iatrogenic and non-iatrogenic reasons [2]. Excessive removal of dentin during coronal enlargement and post space preparation have been reported as contributing factors for vertical root canal fractures [6–8]. The preexisting root morphology and root canal anatomy will influence the degree of dentin removed and residual dentin thickness post root canal instrumentation [9]. Correspondingly, oval-shaped canals become considerably affected when round preparations are created. This results in considerably less remaining dentin thickness, eccentrically in cross-section of the root [6, 10] (Fig. 1.3). The pericervical dentin (PCD) denotes the dentin situated 4 mm coronal and 4 mm apical to crestal bone [11]. It has been demonstrated that the PCD would influence the bending resistance and stress/strain distribution pattern in the root. Increased bending and stress/strain distribution would increase the propensity of vertical root fracture in tooth with reduced PCD [7]. Balancing (a) the degree of root canal enlargement with the requirements of irrigation methods to achieve optimum disinfection and (b) the goal of preserving root dentin during instrumentation so as to maintain the mechanical integrity of the root can be a real conundrum in endodontic practice. The current technological advances have been focusing towards optimizing these goals in root canal treatment.

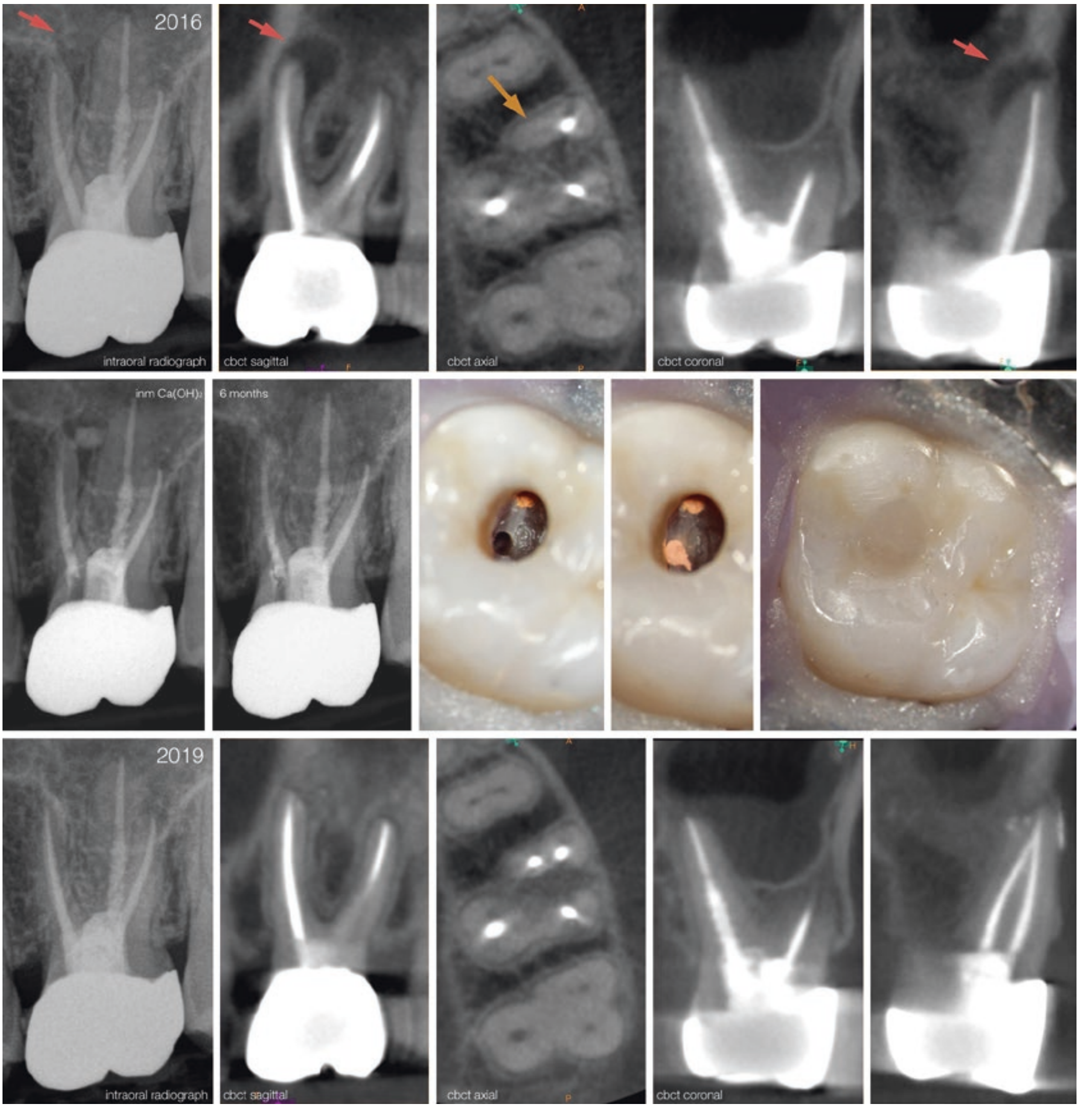

Fig. 1.2 Missing anatomy (untreated canals) is one major failure etiology in root canal treatment. Intraoral radiographs are occasionally able to point out aspects related to this situation (i.e., periradicular pathoses). CBCT slices show them consistently and detailedly. This information (clear visualization of cause and effect) leads to a more precise diagnose and to an appropriate procedure. This particular case was solved with a selective root canal retreatment, the solely reintervention to treat the missed MB2 in two appointments with the use of intracanal medication. 3 years follow-up

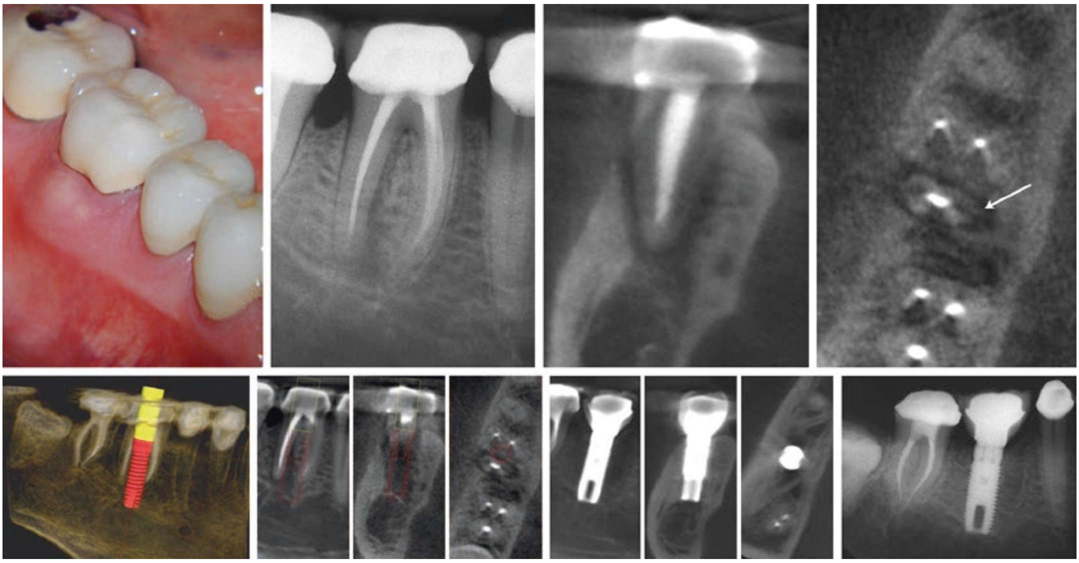

Fig. 1.3 Even though conventional root canal treatment has been reported quite successful (68–85%), cases still fail, including those where despite the fact that accepted protocols have been applied, the structural response is compromised and/or some anatomy may be missed. Presented case is failing after 10 years of endodontic and restorative procedures due to vertical root fracture of the distal root. Classic indication for an osseointegrated dental implant retained crown. Case solved by Dr. Maria del Pilar Rios C (Caracas, Venezuela)

1.2 Technologies for Dentin Preservation: Phase 1—Planning

1.2.1 Cone-Beam Computed Tomography (CBCT) Imaging

Conventional dental radiographs offer a 2D transparency of a 3D object. It has been the standard of practice in dentistry for decades. In endodontics, due to the anatomical and morphological challenges posed by the intricate root canals in the core of the tooth structure, radiological approach has been an invaluable tool to obtain essential information of the anatomical landmarks and morphological characteristics of the pulp chamber/root canals to achieve the established standard of care in root canal therapy. However, the interpretation of dental 2D radiographic images can be challenging due to its inherent limitations such as superimposition of teeth and surrounding dento-alveolar structures, as well as the inability to reveal the true 3D configuration of the dento-alveolar structure [12]. The 2D radiographic interpretations may also be highly subjective and would be influenced by different parameters, such as X-ray beam angulation [13]. The cone-beam computed tomography (CBCT) imaging, on the other hand, provides high-quality 3D views of the tooth and surrounding structures, with interrelation images in three orthogonal planes [14] (Fig. 1.4).

Limited Field of View (FOV) CBCT has been successfully employed in endodontics for a long time now. The current CBCT applications in endodontics includes (a) a variety of clinical situations when intraoral radiographs present inconsistent results, (b) display complex anatomies, for initial treatment of teeth with potential for additional canals, (c) when complex morphology of root/root canal is suspected, (d) for the identification/localization of calcified canals, (e) when intraoral radiographs are inconclusive for the detection of root fractures, (f) in cases of nonhealing treatments, (g) in cases of endodontic complications, (h) certain traumatic injuries, (i)

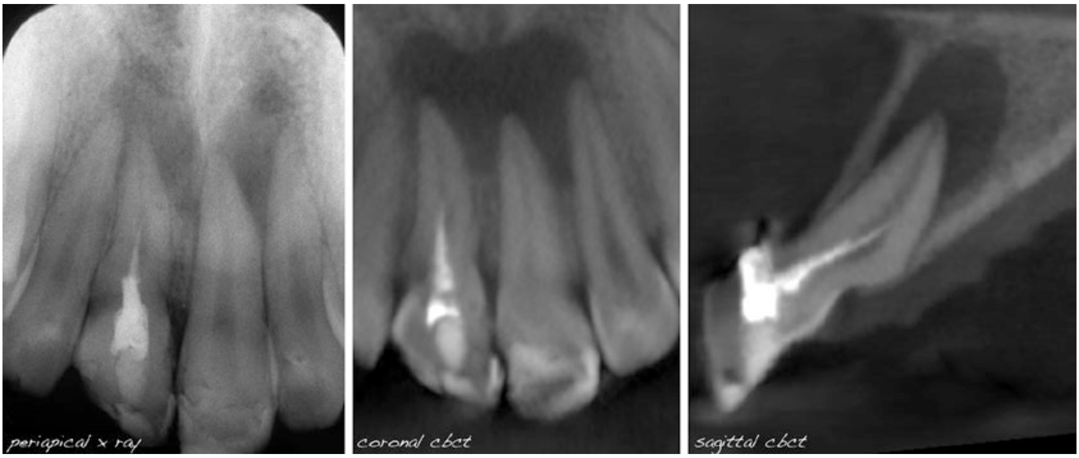

Fig. 1.4 The 2D transparency of a 3D object reveals only what may be observed from such position. In clinical endodontics this means that relevant information for the understanding of the situation might be hidden due to the limitations of a superimposed image. Actual case shows an unusual deviation on the axis from the crown to the root on a maxillary central incisor, not detectable from a conventional buccal X-ray. A lateral view is needed to fully appreciate this condition, as this one provided by a sagittal CBCT slice

in the presence of resorptive defects, and (j) for the outcome assessment in cases when signs and symptoms are present or (k) when FOV CBCT was the imaging modality of choice at the time of treatment [15]. Question arises if any clinical situation is suspected based on the conventional 2D radiographs. Resorptive defects are not always detectable via intraoral radiographs (Fig. 1.5). Even when intraoral radiograph shows a concern, valuable additional information of the concern may be hidden (Fig. 1.6). The potential of extra canals is such an issue. In such cases, without certainty in the knowledge of root canal anatomy, there is always a need to explore for what might be a possibility in the tooth, and this exploration without preexisting knowledge can be at the undesirable expense of dentin tissue.

CBCT scans contain valuable data for less invasive root canal treatments (Fig. 1.7). A detailed evaluation of the preoperatory volume should offer the following information, not clinically presented by other radiographic methods:

- Detection of periradicular lesions
- Determination of the point of entry for root canal treatment
- Assessing anatomical details
  - Size and position of the pulp chamber
  - Number of roots and canals
  - Root canal configuration
  - Root curvatures
  - Working length determination (root length)
  - Canal splitting
  - Horizontal root bulk and canal dimension at pericervical region

1.2.1.1 Detection of Periradicular Lesions

Bender and Seltzer [16, 17] investigated the limitations of intraoral radiography for the detection of periapical lesions. Their study revealed that in order for a lesion to be visible radiographically, the cortical plate of the supporting jaw bone must be engaged. Thus, it turns out that intraoral X-rays are capable of showing some periapical lesions, but in many instances they do not reveal it when present, while CBCT shows periapical lesions consistently [18]. With the use of CBCT, any radiolucent changes at the root apex, related to periapical disease, can be detected earlier than with conventional intraoral periapical radiographs [19]. CBCT slices identified 62% more periapical radiolucent areas on individual roots of posterior mandibular and maxillary teeth,

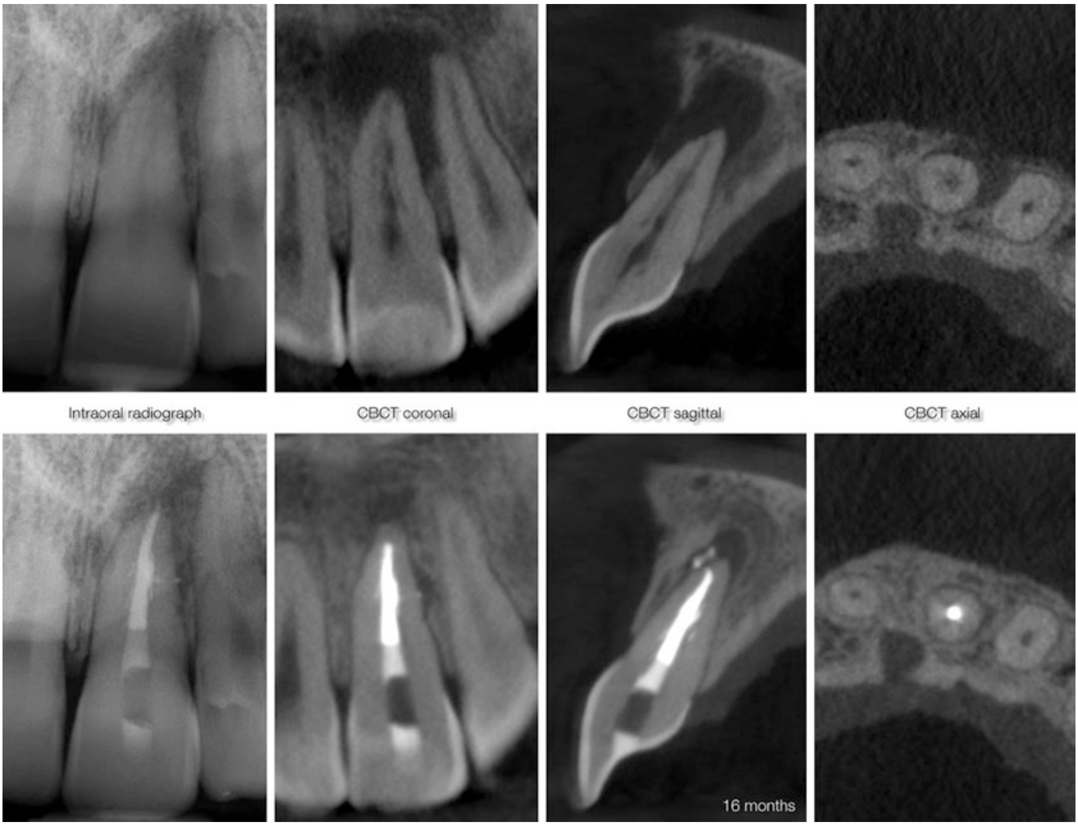

Fig. 1.5 Intraoral radiographs are not always capable to show or suggest the presence of dental resorption clearly, nor show the real condition of supportive structures around an endodontically compromised tooth. This affects the perspective whether a CBCT study is indicated or not when following restrictive indications for the use of such resource. Having the appropriate information ends up affecting the diagnostic impression and the decision-making process regarding the procedures suggested for any condition. Case presented shows an internal resorptive defect not clearly seen in the initial intraoral X-ray. The panorama revealed on the CBCT slices guides the diagnose and the therapy selected. Having proceeded without this knowledge increases failure possibilities. Follow-up on completed endodontic therapy is 16 months. It shows advanced repair, but not complete yet. The tooth remains asymptomatic, later follow-up is guaranteed

compared with intraoral periapical radiographs [12]. Please note that when treated early, the outcome of root canal treatment is more successful [20]. This information is crucial when the presence of a radiolucency is considered determinant in the decision of the number of treatment appointments [21] (Fig. 1.8).

1.2.1.2 Determination of the Point of Entry for Root Canal Treatment

The point of entry is defined as the most convenient location to initiate the preparation of access cavity for endodontic treatment. The most coronal projection of pulp chamber should be considered as an important location for this purpose. Conventionally, the point of entry for root canal treatments is determined generically, without individual considerations. Not considering individual information could affect the selection of point of entry in cases. Trying to obtain this information from intraoral radiographs may lead to incorrect decisions, since conventional radiographs show projection distortions that could create inaccurate suggestions (Fig. 1.9). This landmark may be accurately determined with the use of appropriate CBCT slices. CBCT has proved valuable as a tool for exploring root canal

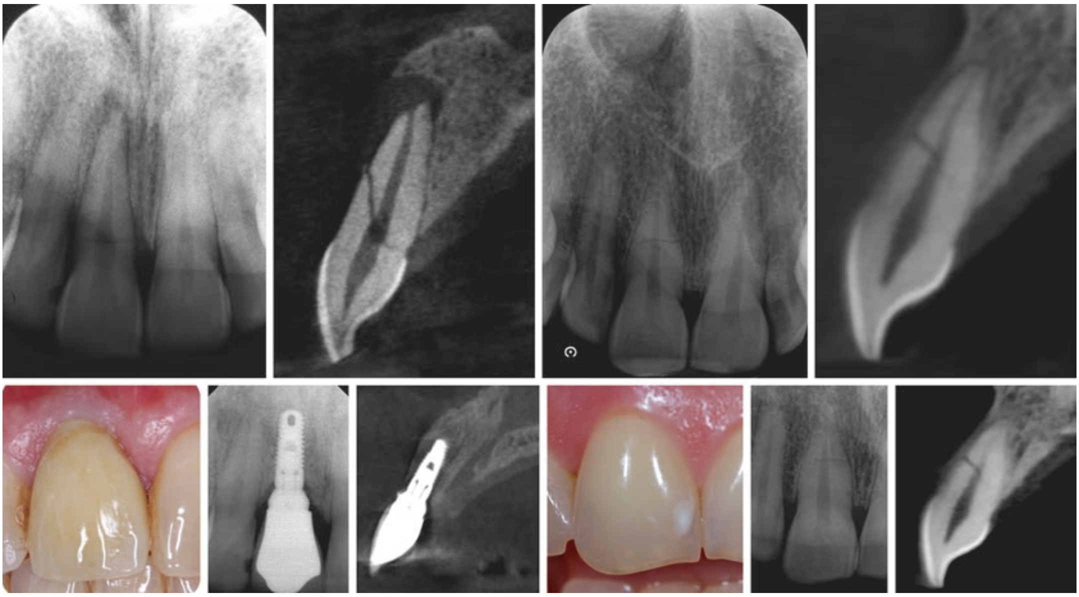

Fig. 1.6 CBCT analysis results quite useful to precisely evaluate cases where conventional X-rays failed to show relevant diagnostic information. These two horizontal fracture cases look quite similar on periapical X-rays: both shows evidence of the fracture and limited bone compromise. Maybe the experienced clinician could suspect these cases are completely different, but confirmation without further intervention is not guaranteed. As comparison CBCT sagittal slice show simply to anyone observing this a whole different situation for each case, regarding size, position and orientation of the dental fracture, and most important, the extension of the bone compromise, leading to two different and opposites approaches: extraction with later implant substitution on the first case, and simple observation with no intervention at all on the second one. Follow-up on each case is 6 years. Implant and regenerative procedures on left case is by Dr. Ernesto Muller & Dr. Luis Alberto García, Restoration by Dr. Tomás Seif (Caracas, Venezuela)

anatomy, as effective as histological sectioning of teeth [22] (Fig. 1.10).

1.2.1.3 Assessing Anatomical Details

Size and Position of the Pulp Chamber

Determination of the pulp chamber parameters is necessary for proper root canal access cavity, no matter which design is intended. Generally, clinicians rely on a tactile feel (the drop of a bur in the pulp chamber), but many teeth do not have enough chamber space for such sensation [23]. For these cases a different strategy is needed. Trying to measure the anatomic landmarks on an intraoral radiograph provides imprecise measurements. Data acquired from CBCT slices are confident to the level of resolution of the acquisition (up to 0.076 μm at this time) (Fig. 1.11). Preservation of the pulp chamber floor is crucial considering that the dentin in this region is a part of the pericervical dentin.

Number of Roots and Root Canals

Preoperative assessment of the root canal anatomy is a key step in root canal treatment [24]. The 2D nature and the anatomical noise associated with intraoral radiographs result in limited information regarding the number and nature of root canals [25]. The etiology of endodontic failure is multifaceted, but a significant percent of failures is related to missed root canal system anatomy. Thus, in endodontic posttreatment failures, detecting missing roots and canals is the foremost issue. Investigations on the incidence of missed root canals in a population present missed canals in 23.04% of the endodontically treated teeth. Teeth with a missed canal were 4.38 times more likely to be associ-