you through. This light can be understood as a source of wisdom. Believing in yourself and in the good things you are doing, within its rational logic and understanding, feeds the self-stimulation of life.

9. Courage – The basic principle of success is never to be afraid of winning it. Courage is a precious diamond for dealing with everyday challenges.

10. Love – Men are afraid to say that word, and especially to put it into practice. The lack of experiencing it makes them hostage to their own ignorance. Common sense loss in the workplace implies the failure of notions of wisdom and reasonableness. Learn to love what you are doing, including life.

Good ambiance and respecting your colleagues are fundamental to professional success and the learning process. I belong to a work team that I am pleased to be part of during teaching and research activities, such as Ana Helena, Daniel Decurcio, Júlio A. Silva, and Patrícia Siqueira. In fact, it is very different because we have common purposes, such as caring about others – humanization.

Thus, I could list a number of requirements for being successful as a professor, but I feel successful in the teaching and research profession, not because of the goods that I have acquired but for the peace and balance I built. At this point, I could either tell the story of those who have told me or tell my story. Most importantly, be happy with what you are doing.

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Impact of a new cone beam computed tomography software on clinical decision-making in Endodontics

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DOI: https://doi.org/10.14436/2358-2545.9.3.020-028.oar

ABSTRACT

The achievements incorporated into endodontics, resulting from new information technologies allowed advances that impacted prognosis and clinical success. These new acquisitions have influenced the contemporary world, that is witnessing a profound change brought about by the speed and quality of information, investment savings and time, thus benefiting the health areas. A revolution in contemporary thinking and living that is being experienced today is biotechnology. The impact of cone beam computed tomography on endodontics was able to overcome several limitations of periapical radiography, such as the removal of overlaps, the extraordinary possibility of image navigation, the quality of high resolution and contrast images, among others. This study aims to present some characteristics of a new cone beam computed tomography software named e-Vol DX which may impact the clinical decision-making in endodontics. The e-Vol DX CBCT software is an indispensable resource for high quality images. Various filters with different properties have been developed and incorporated, such as the Blooming Artifact Reduction (BAR) filter that allows the reduction of white contrast artifacts, among others. This tool is effective in clinical decision-making for the implementation of the therapeutic protocol of complex endodontic cases.

Keywords: Artifacts, Diagnosis, e-Vol DX, Software, Cone-Beam Computed Tomography, Root Canal Treatment.

How to cite: Bueno MR, Estrela C. Impact of a new cone beam computed tomography software on clinical decision-making in Endodontics. Dental Press Endod. 2019 Sept-Dec;9(3):20-8.
DOI: https://doi.org/10.14436/2358-2545.9.3.020-028.oar

» The authors participated in the development of this new software.
» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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Submitted: July 23, 2019. Revised and accepted: August 19, 2019.

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Introduction

The successful root canal treatment should always be the main objective in all clinical situations, avoiding tooth loss as much as possible. Understanding the risk factors associated with failures warns of the importance of safe execution of therapeutic procedures during root canal treatment. The achievements incorporated into endodontics resulting from new information technologies allowed advances that impacted on the prognosis and clinical success. These new acquisitions have influenced the contemporary world, which is witnessing a profound change brought about by the speed and quality of information, investment savings and time, thus benefiting the health areas. A revolution of contemporary thinking and way of life that is being experienced today is biotechnology.[1,2]

The impact of cone beam computed tomography (CBCT)[1,2-7] on endodontics was able to overcome several limitations of periapical radiographs, such as the removal of overlaps, the extraordinary possibility of image navigation, the high quality of the image with resolution and contrast, among others.[2-7]

Numerous studies have been developed using CBCT analyzes to determine the accuracy in identifying periapical lesions and root resorption,[8-12] involving the complexity of the dental anatomy, the relationship of the root apices of the posterior maxillary teeth with the maxillary sinus, the morphological characteristics of root canal preparation, besides the new methodologies.[12-28] A prominent aspect in CBCT studies is the possibility of knowing the age and gender of the individuals involved in the researches, the characteristic of constituting a non-destructive methodology in relation to samples with potential to be analyzed in real time, which differentiates this image examination method of the others.[24,27]

The characteristics of the successful root canal treatment (absence of pain, regression of apical periodontitis (AP), root and coronary canal space completely filled, and tooth function) should be evaluated over time.[14] In cases of doubt about success or failure of root canal treatment, the correct localization or detection of apical periodontitis can be done by CBCT scans. The possibility of map-reading on the CBCT images with the use of new CBCT software (e-Vol DX) may characterize a different reality than a multidimensional structure, based on accurate information about the presence, absence or regression of apical periodontitis, root resorption, root fracture, root perforation, presence of isthmus, presence of lateral root canal, among other complex clinical conditions.[26-29]

This study aims to present some characteristics of a new cone beam computed tomography software called e-Vol DX, which impacts in the clinical decision-making in endodontics.

Application Clinical of new CBCT Software (e-Vol DX)

Cone beam computed tomography represents a technology that allows three-dimensional visualization of anatomical structures and pathological processes. However, it has lower radiation dose and a better image quality when compared to medical tomography. Various factors may interfere with the final result of the CBCT image quality: 1) area sensor type, air gap (space between X-ray emitter and sensor), patient stabilization system (patient immobilizer), CT scanner column stability, voxel size, field of view (FOV), tube head focal point size, volume noise, dynamic image range, X-ray parameters kilovoltage and milliamperage, native acquisition software, scanner calibration; 2) patient - density of complex craniofacial structures, patient stability, patient position, amount and density of materials in the patient's mouth; 3) software - general software design, image editing design, dynamic image range, sharpness of noise and margin size controls, artifact reduction, functional 3D (multi-way browser), multidirectional browser, compression with or without lost data logging, oblique coordinate logging, registration of filter settings for replication, specific search tools and images in the Digital Imaging and Communications in Medicine (DICOM) format.[2]

Cone beam tomography devices have their own characteristics and differ in sensor type, field of view (FOV) size, resolution and software. These differences make certain devices better suited for certain specialties, where a high-resolution image is needed, unlike specialties where you need a larger area of great volume. Cone beam tomographs export DICOM standard image. Patient data can be sent to a prototyping laboratory to make solid, physical models that are accurate, tactile and three-dimensional representations of the patient's anatomy. They are especially used in cases involving planning with complex approaches.[2]

In the CBCT exam, the radiation dose is slightly higher than the periapical radiography, and much lower than in the medical tomography. The European Society of Endodontics and the American Association of Endodontics - and the American Academy of Oral and Maxillofacial Radiology understand that the benefits should outweigh the potential risks to the patient for the indication of a CT scan, with periapical radiography being the first choice. The indication of the CBCT exam directs to the complex cases, where this exam is inconclusive and does not allow a correct planning and a perfect decision making. The principle of radiation safety must always prevail, whose name in radiology is ALARA (as low as reasonably achievable).[30-37]

Despite the technological advancements in CBCT hardware, the interpretation of the acquired images is still compromised by viewing software packages that often have limited navigational tools and lack adequate filters to overcome some challenges of the CBCT technology such as artifacts[26] recently, Bueno et al.[26] reviews the current limitations of CBCT and the potential of a new CBCT software package (e-Vol DX, CDT- Brazil) to overcome these aspects and support diagnosing, planning and managing of endodontic cases. This imaging method provide high resolution images due to submillimeter voxel sizes, dynamic multi-plane imaging navigation and ability to change the volume parameters such as slice thickness and slice intervals and data correction applying imaging filters and manipulating brightness and contrast. The main differences between e-Vol DX and other software packages are: compatibility with all current CBCT scanners with the capacity to export DICOM Data, a more comprehensive brightness and contrast library, as other applications, in which adjustments are limited, do not usually support all the DICOM dynamic range features; Custom slice thickness adjustment, often limited and pre-defined in other applications; Custom Sharpening adjustment, often limited in other applications; advanced noise reduction algorithm that enhances image quality; preset imaging filters, dedicated endodontic volume rendering filters with the ability to zoom the image over 1000x (3D reconstructions) without loss of resolution and automatic imaging parameters customization for better standardization and opportunities for research; capture screen resolution of 192 dpi, with a 384 dpi option, in contrast to the 96 dpi of most similar applications. This new CBCT software package may support decision-making for the treatment of complex endodontic cases and improve diagnosis and treatment results. Effective improvement of image quality favors the rational prescription and interpretation of CBCT scans.[26]

The application of e-Vol DX software was used to determine the position of the apical foramen in relation to root surfaces of human permanent teeth.[27] The position of the apical foramina was central in the upper and lower human permanent teeth in 48.95% and 42.08%. CBCT images analyzed by e-Vol DX can be used to determine the true anatomical position of the apical foramen, constituting a useful tool for non-surgical and surgical endodontic planning and treatment.[27] In other study, Bueno et al.[28] discussed a method to determine the root canal anatomic dimension by using e-Vol DX software. The methodology consists in initially establishes the correct positions which will be measured, define the point on the edge of the anatomical structure, and next adjust the intermediate position in the grayscale of CBCT image. Thin sections (0.10 mm) are obtained from 3D reconstructed slices in the filter for the measurements, in order to determine the edge of the anatomical surface in the axial plane. A replication of positions in 3D mode is done in multiplanar reconstruction (MPR) of CBCT images, where the correct position is established with the aid of a positioning guide. The 3D density is adjusted so that it is in the same dimension as the 2D image, and a dimension calibration occurs to the point where there is a coincidence between 3D and 2D. This calibration is done only at the beginning of the measurement. Next, the intermediate position of the division between the grayscale is verified in the CBCT scan. Once one side has been completed, it is moved to the other side and follows the same guidelines described above. When setting the position of the courses in the other margin, being that 2D mode is used as reference. Thus, one obtains the required measure, being checked in the two points. The creation of this filter in the e-Vol DX software for measurement, and its appropriate management, allows more effective applications when it is desired to obtain diameters of anatomical structures.[28]

Thus, several filters have been developed to increase the effectiveness of imaging exams with the application of e-Vol DX. In clinical practice, the analysis of supernumerary and accessory root canals, especially small ones, is a real challenge. Often, the dimensions of images can make essential information go unnoticed, compromising the interpretation of the image.

The ACI (Accessory Channel Identification / Navigation) filter is a feature that enables image enlargement, enabling you to identify root canals in detail and clarity, however small. The use of this filter combined with multiplanar reconstruction (MPR) - in addition to the indexing of 3D planes associated with 2D reveals essential, previously unnoticed information. This is not just about better visualization, but an effective way to reveal details, which is fundamental for clinical diagnosis. Therefore, although it is an adjunct, the ACI filter impacts both the radiologist's work and the end product to be delivered to the endodontist. Among the advantages of the ACI filter are: - high quality viewing of small structures - magnification of the 3D image more than a thousand times; - Combined with other filters, it is a powerful aid for diagnosis determination; - Clarity and detail in the image (Fig 1 A-C).

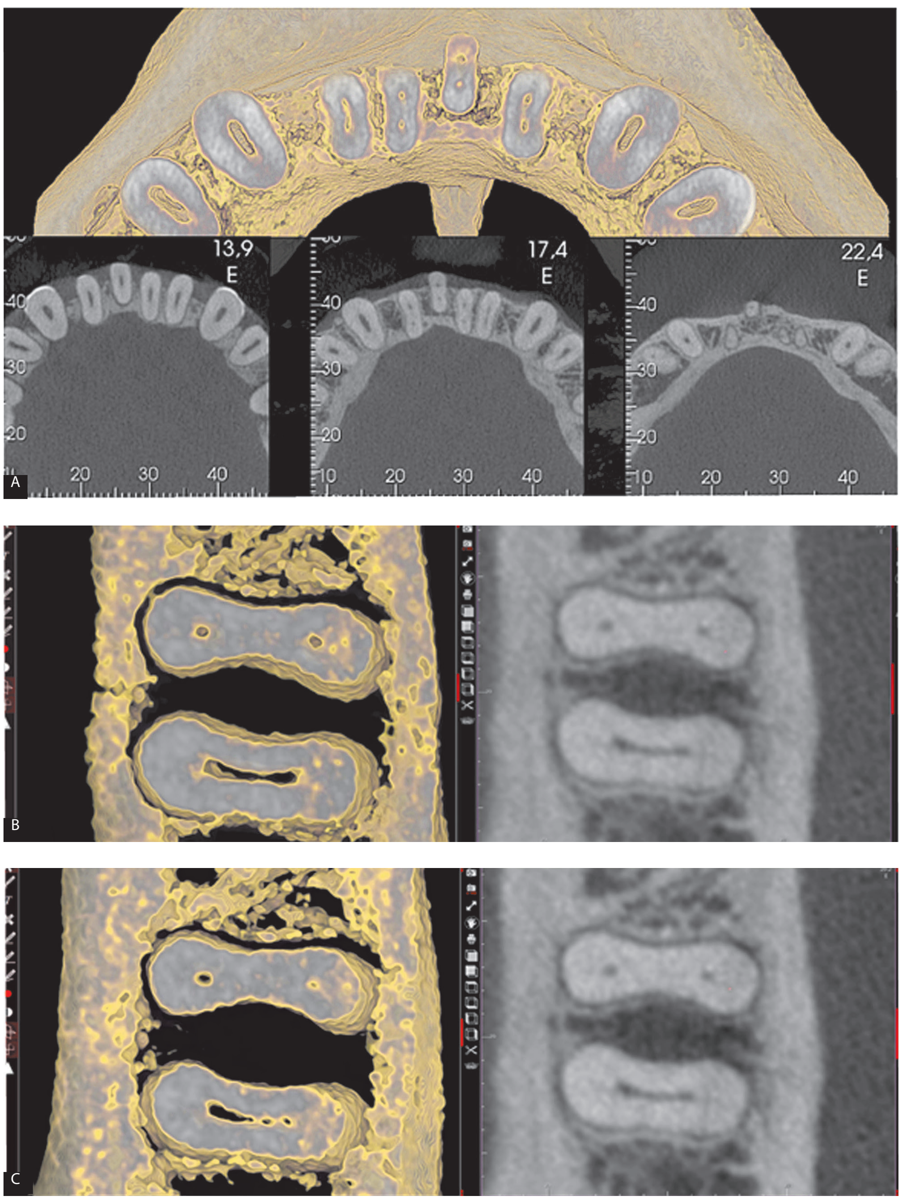

Figure 1. The ACI filter has a feature that enables image enlargement allowing the identification of root canals with details and clarity. The use of this filter combined with multiplanar reconstruction (MPR), in addition to indexing 3D planes associated with 2D reveals essential, previously unnoticed information identifying channels not visualized in 2D images.

Another PH (Pulp Horn) filter allows to transform the CBCT images in transparent mode, as shown in Figure 2 A-B. Specific details of the coronary chamber as well as volume and adjacent structures are clearly visualized. An interesting feature of the PH filter, when used for didactic purposes with 3D navigation, changing inclinations and positions is the pulp horn's spatial visualization functionality, not only as flat prominence, but in all its three-dimensional aspect.

The Endodontic Filling (EF) filter is very effective in teaching functionality, as it allows a 3D view of the root canal filling, allowing image rotation and view of the whole structure. In addition, it allows one to observe, for example, how far the filling material has been able to penetrate in open spaces. A good applicability for the images generated by the EF filter is the assembly of three-dimensional quality analysis videos of root canal treatments. Advantages of this filter include: - 3D view of root canal filling; - differential in didactic presentations; - assistance in assembling videos for presentations; - structure assembly view (Fig 3 A-B).

The Blooming Artifact Reduction (BAR) filter offers great differential for CT scans where there are metallic elements and dense materials that result in white contrast artifacts overlapping many real details. The white contrast artifact has magnification rate ranging from 9 to 100%, i.e., with this distortion, the accuracy to measure areas with this type of interference is lost. Another consequence of these artifacts and inaccuracies is the difficulty in visualizing internal areas of implants. All of this implies the loss of essential information for accurate diagnosis and treatment. The BAR filter allows you to solve these problems and ensures diagnostic accuracy. In addition to providing the actual size visualization of the observed area, it reduces magnification, and eliminates white contrast artifacts making it possible to view information of extreme relevance to the diagnosis (Fig 4 A-B).

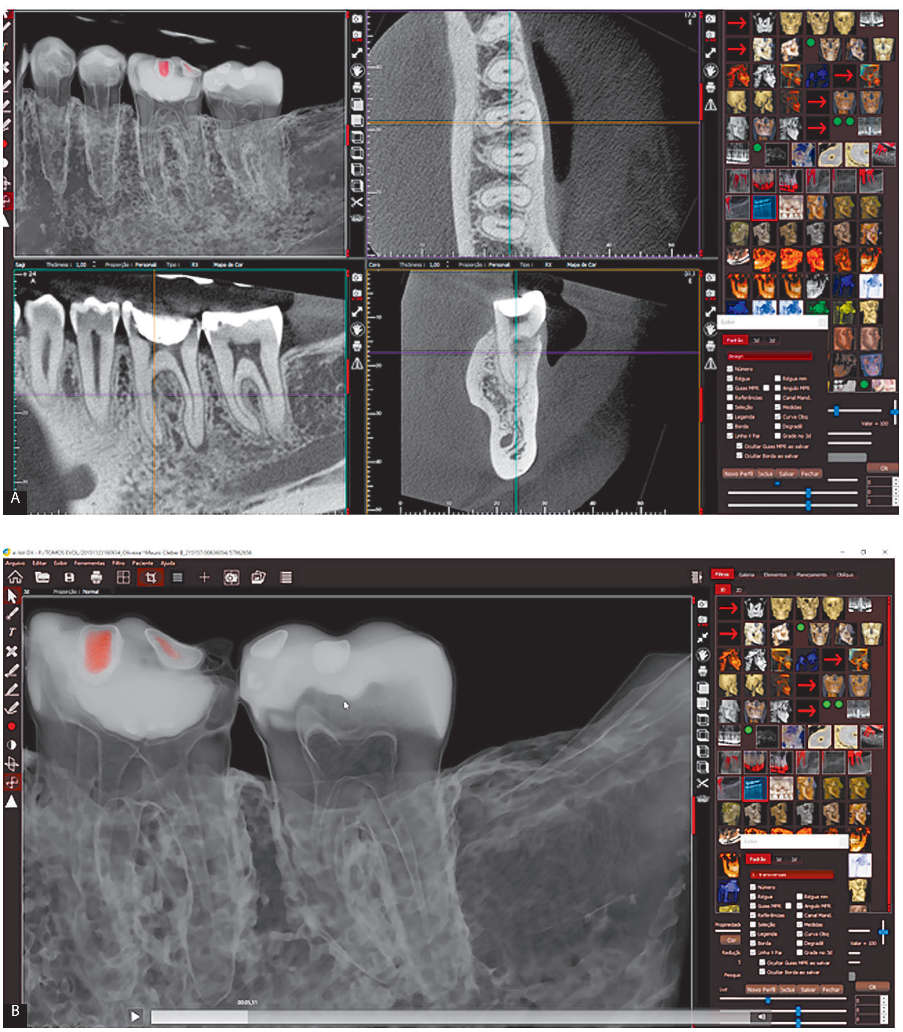

Figure 2. This filter allows CBCT images to be transformed in transparent mode, into images with specific coronary chamber details, as well as clearly visualized volume and adjacent structures.

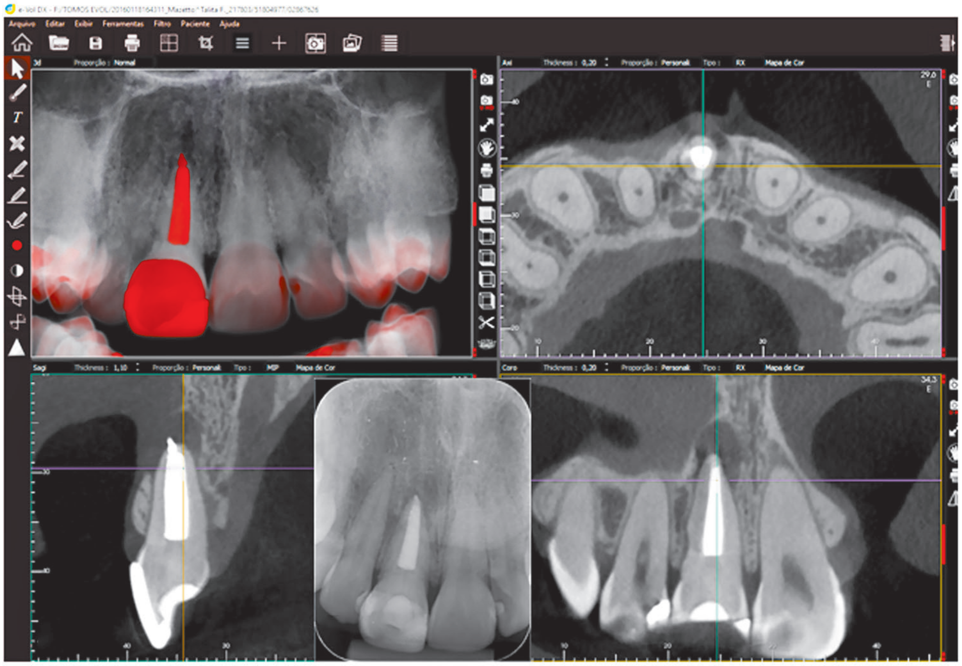

Figure 3. The EF (Endodontic Filling) filter is effective in teaching functionality, as it allows a 3D view of the root canal filling, allowing image rotation and view of the whole structure. A good applicability for the images generated by the EF filter is the assembly of three-dimensional treatment analysis videos.

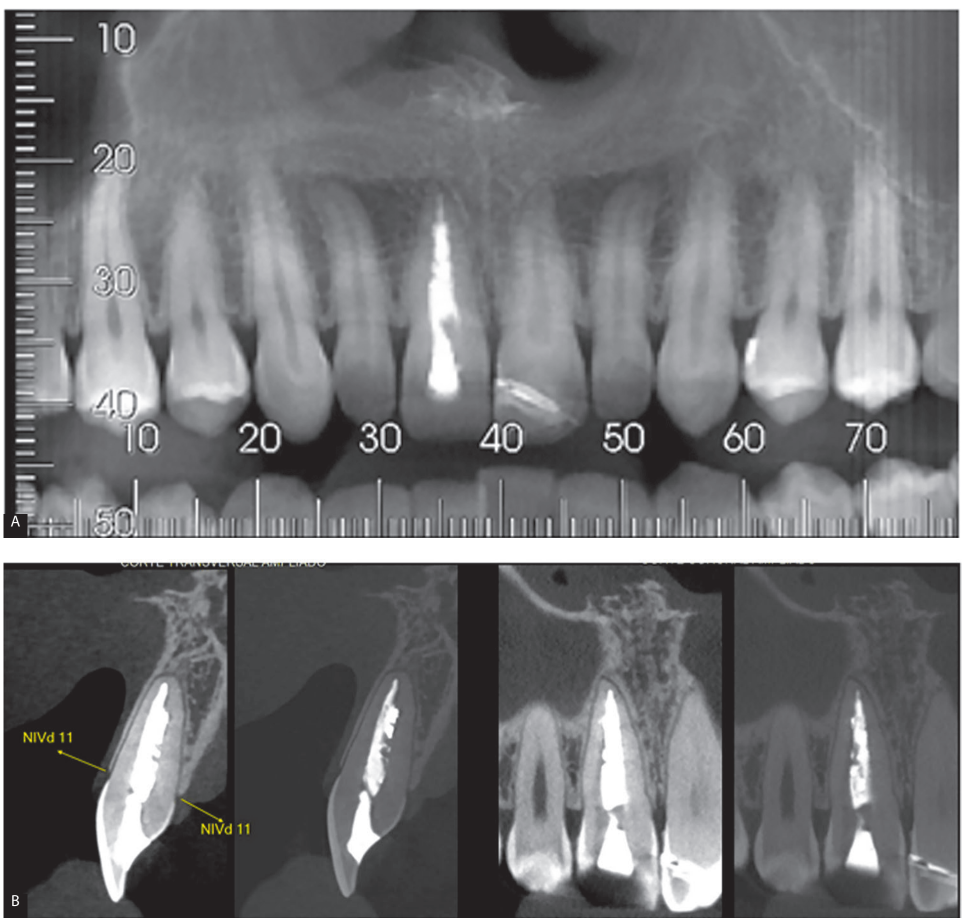

Figure 4. The Blooming Artifact Reduction (BAR) filter offers differential for CBCT exams where there are metallic elements and dense materials that result in white contrast artifacts overlapping many details. The BAR filter provides visualization of the actual size of the observed area, reduces magnification, and eliminates white artifacts making it possible to view information of extreme relevance to the diagnosis.

The PC (Pulp Cavit) filter makes it possible to visually remove the dentin structure, making the alveolus and pulp cavity visible. Thus, it is possible to observe in detail accessory root canals. The set through 3D navigation facilitates decision-making about endodontic instrument selection, as well as the root canal enlargement limit, as well as numerous other properties (Fig 5).

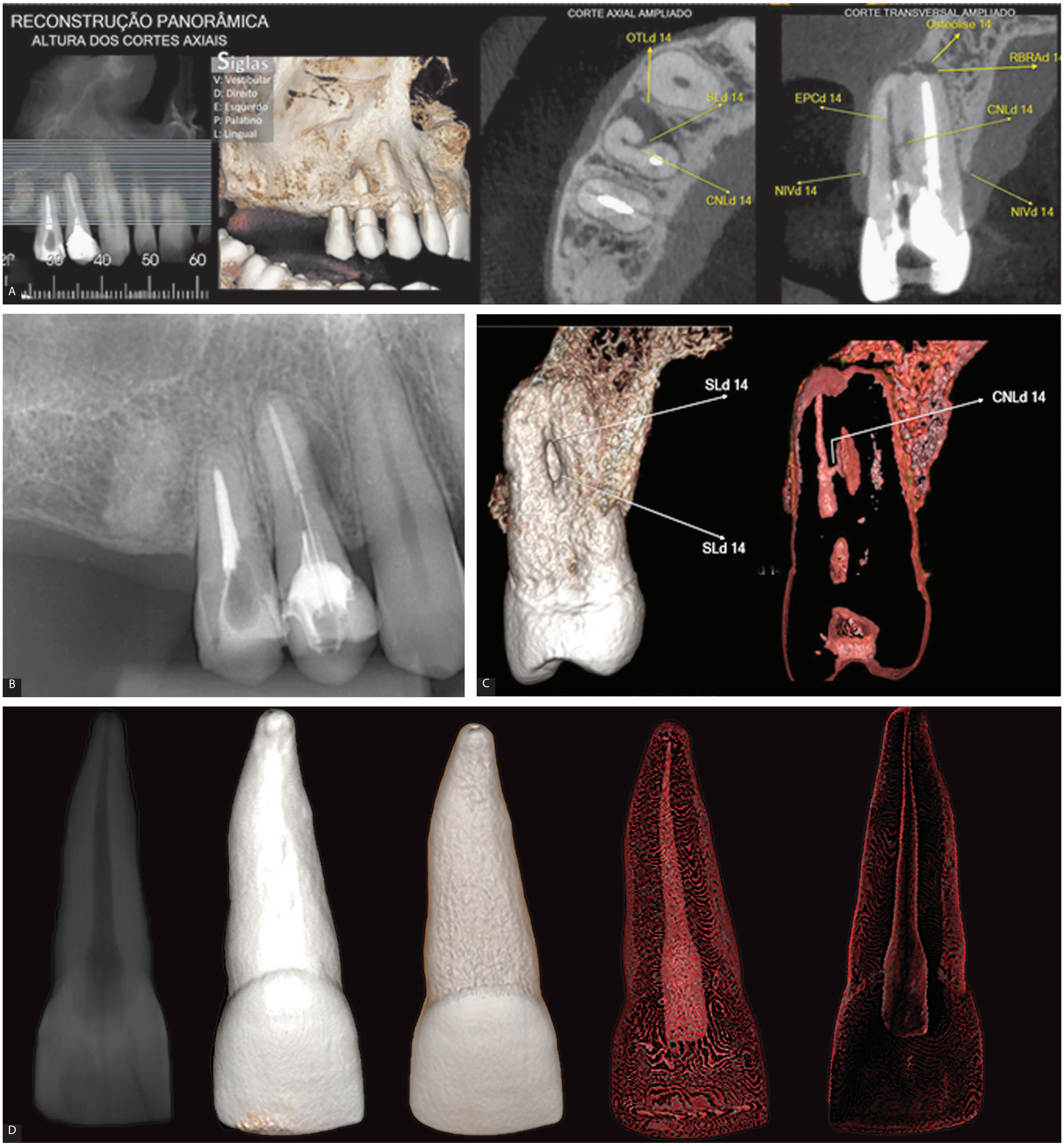

Figure 5. The PC (Pulp Cavit) filter allows visually removing the tooth structure, leaving visible only the socket and the pulp cavity. In 3D navigation, it facilitates decision-making on endodontic instrument selection as well as the root canal enlargement limit.

Discussion

The scientific revolution in the field of technology has enabled countless promising expectations in CBCT imaging. The knowledge about CBCT technology and its repercussions in dentistry has been evident. Sharp images, sophisticated software and fully computerized stock photography incorporate these new advances. The CBCT scans allows the best results in imaging exams of oral cavity hard tissue, with the possibility of dynamic navigation in multiple planes, including depth.[1,2]

The interpretation of these aspects associated with the structures of the buco maxillofacial and dental complex by using periapical radiography has always been a great challenge for the professional. The correct identification of periapical bone destruction implies destruction of one of the corticals, or 30 to 50% of periapical bone loss.[38-40] This new technology, an important exam to complete the diagnosis has motivated several studies involving its application in dentistry, with high precision compared to conventional exams. This new technology has enabled the institutionalization of new study patterns, researches, including new developmental of index of human dentition, changes and analysis of dental anatomies, new index to assess periapical lesions, root resorption, root perforation, root fracture, bone thickness, identification of pathologies, errors in surgical procedures, healing process repair, among others.[15-29] The proper indication as well as the interpretation of CBCT images are essential elements in clinical management with a view to achieving therapeutic success.[14]

The impact of misinterpretation of periapical radiographs and CBCT images may have unpleasant consequences for the therapeutic protocol.[14,26-29] In this sense, a new direction has been signaled with the purpose of solving these drawbacks resulting from the artifacts observed in CBCT images associated with metallic or solid structures.[26] In this direction, a new CBCT software has been proposed and assisted in solving these challenges, the e-Vol DX software.[26] Several filters incorporated in this software may assist with blooming artifact reduction (BAR) while producing significant improvement in image quality.

Conclusions

The e-Vol DX CBCT software is an indispensable resource for high quality images. Various filters with different properties have been developed and incorporated in this imaging exam, such as the Blooming Artifact Reduction (BAR) filter that allows the reduction of white contrast artifacts, among others. This tool is effective in clinical decision-making for the implementation of the therapeutic protocol of complex endodontic cases.

Acknowledgments

Supported in part by grants from the National Council for Scientific and Technological Development (CNPq grants 306682/2017-6 to C.E.).

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