Available online at www.giornaleitalianoendodonzia.it

CASE REPORT

Successful treatment of a damaged upper molar using 3D Technology: a case report with 4 years follow-up

ABSTRACT

Aim: *To describe, in a stepwise manner, the diagnosis, treatment planning, execution, and rehabilitation of damaged upper molar using Sicat Endo software and a computer-aided design/computer-aided manufacturing (CAD/CAM) system.*

Summary: *A patient with no painful symptoms presented to our clinic to complete a treatment that had been initiated a year ago (left unfinished for personal reasons) to save the tooth. Clinical tests indicated a previously initiated therapy and normal apical tissues. Cone beam computed tomography (CBCT) was used for the diagnosis and treatment planning of the root canal procedure. The planning of the previously designed access cavity and identification of all the root canals was performed with Sicat Endo software (Sicat, Bonn, Germany). Additionally, the quality of the final root canal obturation was evaluated using Sicat Endo software. The final crown restoration was fabricated using a CAD/CAM system and pressed lithium disilicate material. The present case report revealed a successful four-year follow-up of a one-session endodontic treatment of a maxillary molar and CAD/CAM final restoration using digital technologies and 3D software.*

Key learning points

- *In the present case report, Sicat Endo Software was used for root canal treatment planning and for assessing the quality of final obturation.*
- *The present case report utilized CAD/CAM technology for one-session treatment.*
- *This case report presents a middle-term follow-up of four years on the use of digital technologies for one-session endodontic therapy and prosthetic rehabilitation.*

Bogdan Oprea[1]

Maria Mihaela Iuga[2*]

Fernando M. Espada Salgado[2]

Kavalipurapu Venkata Teja[3]

Artur Grila[4]

Dan Herschbach[5]

Bianca Oprea[6]

Michele Simeone[7]

[1]*Department of Dental Morphology, University Lucian Blaga Sibiu, Romania*
[2]*Faculty of Health Sciences, Private University of Tacna, Tacna, Peru*
[3]*Department of Conservative Dentistry and Endodontics, Mamata Institute of Dental Sciences, Hyderabad, Telangana, India*
[4]*Private practice "Zahnlounge", Linz , Austria*
[5]*Private practice "Zhanartz im Schwabikum", Munich, Germany*
[6]*Private practice "Regina Maria Dental Clinics Sibiu", Sibiu, Romania*
[7]*Department of Neuroscience, Reproductive sciences and Dentistry, University of Naples, Naples, Italy*

Received 2024, August 23
Accepted 2024, September 26

KEYWORDS *CBCT, Sicat Endo, Digitalization, Cad-Cam, root canal treatment, indirect restoration.*

Corresponding Author
Maria Mihaela Iuga | Avenida San Martin, N° 884, Tacna | Perù.
Phone: +51935499554 Email: maria.iuga@unjbg.edu.pe

Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2024.38.01.17

Introduction

Endodontic treatment has been demonstrated to be a predictable procedure, with effective canal disinfection and root canal obturation (1). Guillen et al. in a systematic review and meta-analysis revealed that all aspects of restoration impact the overall outcome (2). A satisfactory coronal restoration significantly improves the result of root canal treatment, using "healthy periapical tissues" as a measure for success (3). A clinical prognosis study showed that if the final restoration was completed in less than a week, the success rate was 82.4%, compared to cases where the restoration was placed after more than a week, which had a success rate of 49.1% (4). A significant association between the type of restoration and "tooth survival" has been documented (5). Higher survival rates for teeth restored with indirect restorations compared to those restored with direct restorations have been reported (6). Endodontic procedures can be made more comfortable and efficient with the use of digital imaging, 3D software planning, and advanced instrumentation. Cone beam computed tomography (CBCT) imaging is an indispensable tool in the diagnosis and treatment planning of root canal treatment due to its enhanced capacity to reveal the detailed morphology of the endodontic system and to locate calcified root canals (7).

3D virtual planning software, such as Sicat Endo (Dentsply Sirona), has been specifically designed for assessing root canal anatomy and determining preoperative working length. A recent study highlighted the usefulness of 3D planning software and CBCT for evaluating root canal anatomy and working length determination, while reducing residents' stress levels (8). Another study compared the accuracy of 3D endo software in determining working length using preoperative CBCT scans and an electronic apex locator intraoperatively in human extracted teeth. The results found no statistical difference between the measurements but suggested that, for cases with a preoperative CBCT scan available, 3D software could accurately determine working length (9). The development of CAD/CAM technology has opened new horizons in dentistry, providing precision, aesthetics, and restorative procedures that consume less time (10).

The aim of the present case report was to demonstrate a step-by-step 3D treatment plan, from diagnosis to endodontic treatment and final CAD/CAM restoration of a severely damaged maxillary molar. In the literature, there are several case reports on the use of digital technologies in endodontics, including one involving a destroyed molar with a 14-month follow-up.

Report

A 38-year-old female patient presented to our clinic to complete the treatment that was started a year ago to save element 2.6. She reported no painful symptoms, only masticatory discomfort caused by coronal destruction. The patient wishes to finish the treatment that was interrupted for personal reasons. Clinical tests indicated negative results for palpation, percussion, and vitality, with no periodontal pockets, suggesting a previously initiated therapy and normal apical tissues. The clinical examination revealed a temporary distal occlusal restoration on tooth 2.6, associated with significant loss of dental substance. The vestibular, palatal, and mesial walls were still intact (Figure 1). The mesial marginal ridge has a crack caused by existing caries on the mesial surface. Clinically, there the remaining tooth structure was enough to allow field isolation and safe execution of endodontic treatment. The patient's consent was obtained, and her medical history was not contributory. PRICE 2020 guidelines were used to report the current case. The proposed treatment plan includes the following stages: initial CBCT scan, optical impression, digital treatment planning, performance of endodontic treatment, CBCT scan control, and final coronal restoration.

Initial CBCT Scan

A CBCT scan was performed using the Orthophos SL3D with a 5 x 5 cm 80 voxel

Figure 1
Initial situation. Clinical aspect of tooth 2.6. The presence of a provisional restoration and a significant level of coronal destruction can be observed.

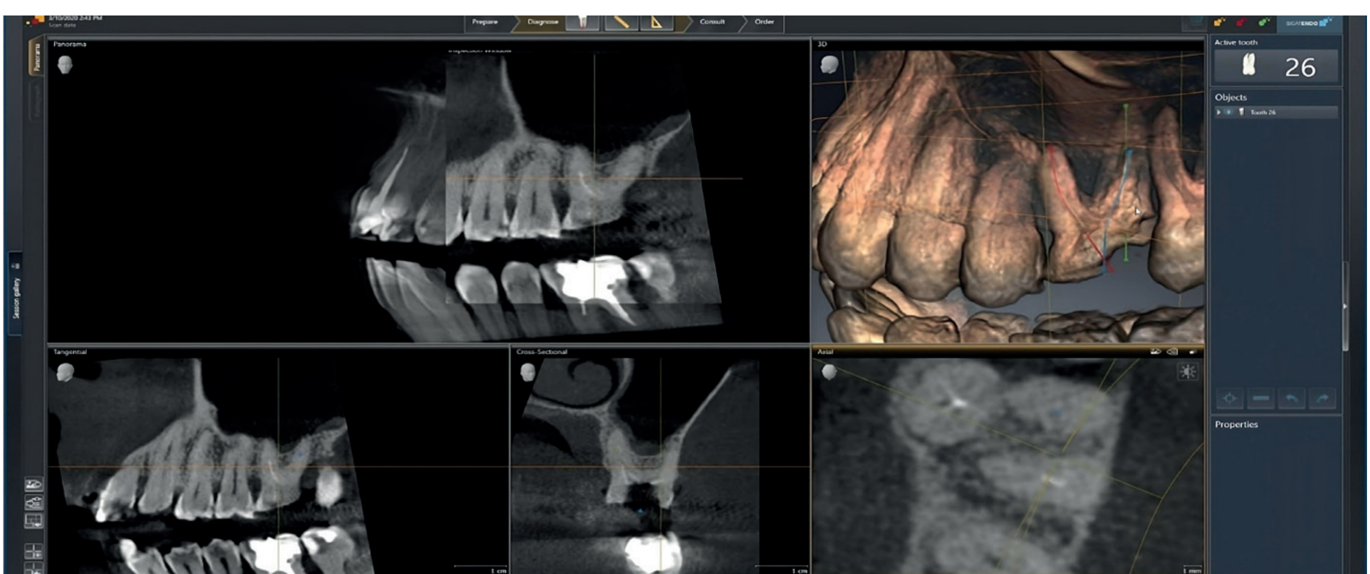
setting (Dentsply Sirona, Bensheim, Germany) and analyzed using Sidexis4 imaging software (Dentsply Sirona). The initial radiological examination demonstrated the presence of a previously incomplete endodontic treatment, with no evident apical hypodensity, except for slight hypodensity in the distal buccal root (Figure 2).

Digital Impression
An optical impression of the initial situation (Figure 3) was obtained using the PRIMESCAN system (Dentsply-Sirona, Bensheim, Germany) with Cerec SW 5.1 software. In this case, the access cavity was already created, making it unnecessary to export the optical print to the Sicat Endo application. For cases requiring access cavity planning, an optical impression is exported in .sxid format to the Sicat Endo application, which allows for the identification and stabilization of access into the root canals in a predictable manner, thereby reducing instrument stress.

Digital Endodontic Treatment Planning
The initial scan was then opened in the Sicat Endo application for analysis of the tooth's endodontic system and preliminary planning. The planning stages included: establishing the tooth for analysis (in this case, tooth 2.6), determining the tooth's axis, and tracing the four root canals (MB1, MB2, DB, P) from the occlusal surface to the apex for each canal. The Endoline function was utilized with the aid of the two Endoview windows, allowing for 360-degree image rotation around the Endoline. This facilitated necessary corrections to ensure that the Endoline was centered on the root canal along its entire length. The lengths of the four canals were measured simultaneously during the tracing process (Figure 4).

Performing the Endodontic Treatment
Endodontic treatment was carried out using the Zumax 3200 operating microscope (Zumax, China) for photo and video documentation of the treatment stages. After anesthesia with Ubistesin Forte (4% Articaine with 1:100,000 epinephrine; 3M Deutschland GmbH, Germany), rubber dam isolation was achieved using the KKD®

Figure 2
Initial CBCT. Radiographic examination within the SICAT ENDO application. The presence of an incomplete endodontic treatment is observed.



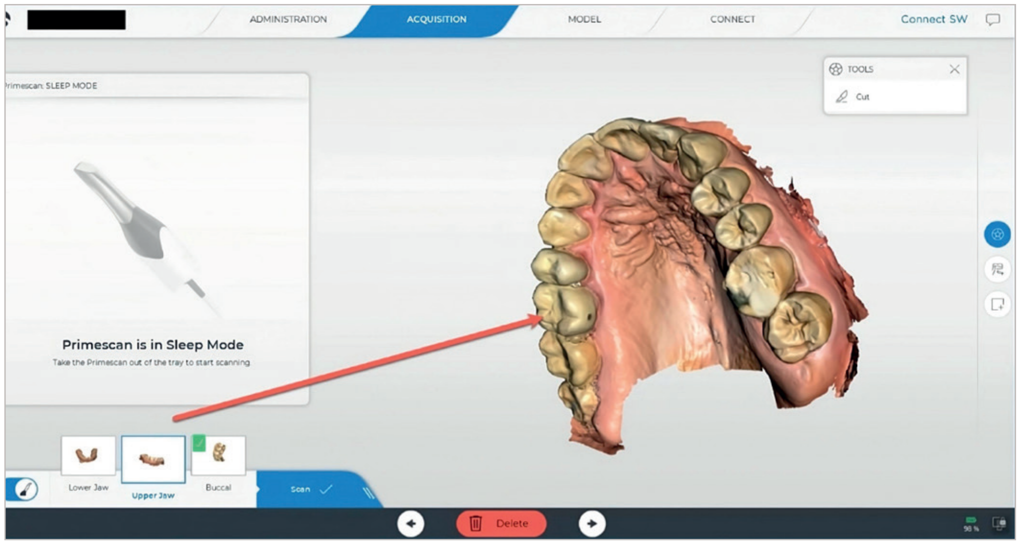


Figure 3
Optical impression of the initial situation.

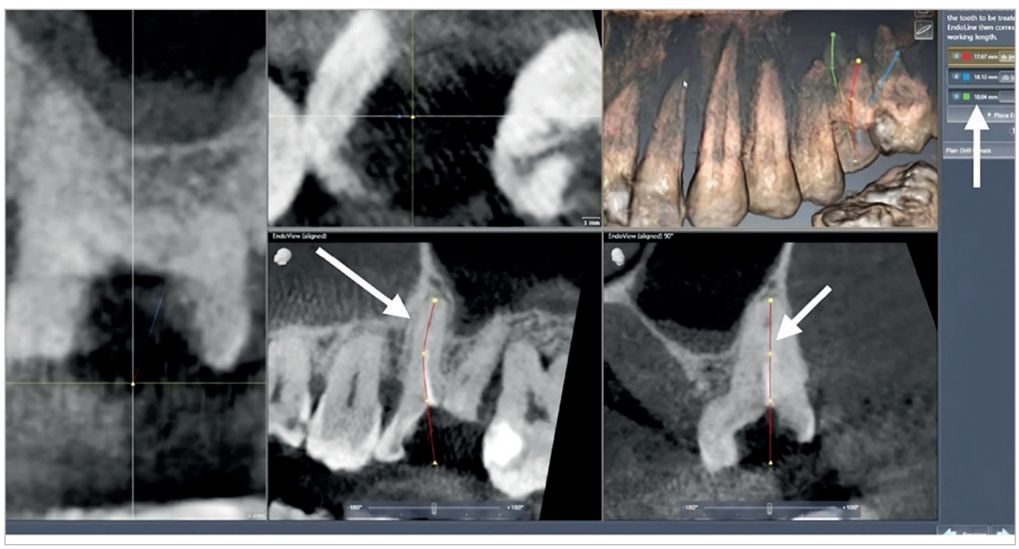


Figure 4
Image during the planning of endodontic treatment in the Sicat Endo application. The white arrows indicate the usage of Endoline for determining the precise route and length of the root canal.

Rubber Dam Starter Kit (KKD, Ellwangen, Germany) and a soft clamp (Kerr, USA) for fixation. All existing temporary filling materials were removed (Figure 5A), and four root canals were located using the Satelec P5 Newtron XS system with the Endosucces loop kit (Acteon Group, UK). Following the removal of previous obturation materials, cleaning and shaping were completed with rotary system files (Dentsply-Maillefer).
The ATR Teknika motor (Dentsply - Maillefer) was used with a specific program for the ProTaper system, alongside the apex locator Raypex 6 (VDW, Germany) (Figure 5B). Disinfection involved alternating irrigation with 2.5 ml of 5.5% sodium hypochlorite (NaOCl) and 17% ethylenediaminetetraacetic acid (EDTA) between each instrument using a plastic syringe and a 30G NaviTip (Ultradent Products Inc.). A final disinfection was carried out with 5.5% NaOCl and 17% EDTA, activated three times for 20 seconds with ultrasonic activation (Figure 5C).
The four gutta-percha cones were calibrated according to the working length, the diameter of the last instrument used, and the apical diameter. Obturation of the root canals was performed using gutta-percha points and AH Plus sealer (Dentsply Detrey, Konstanz, Germany) (Figure 5D) with the warm vertical condensation technique using the BeeFill 2 in 1 system (VDW, Mu-

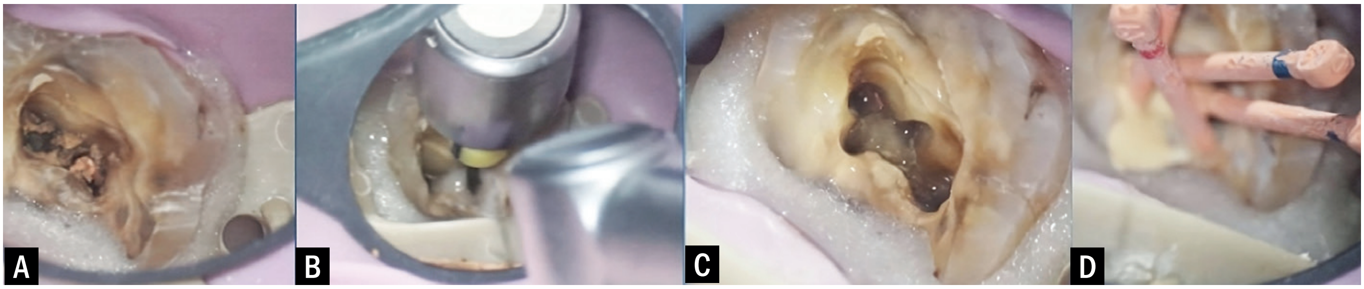


Figure 5
Images during the endodontic treatment. **A)** Identification of the entrances to the root canals. **B)** Canal preparation. **C)** Final irrigation. D) Placement of gutta-percha cones loaded with sealer.

nich, Germany) and FANTA gutta-percha pluggers (FANTA, China) calibrated for each canal. After completing the root canal filling, the pulp chamber was cleaned with isopropyl alcohol to remove remnants of the sealer. The pulp chamber was sealed with flowable composite following the classic adhesive protocol (acid etching, thorough washing with light pressure, adhesive application, photopolymerization, flow composite application, photopolymerization, gel application to inhibit the oxygen layer, photopolymerization, and gel washing).

Control CBCT Scan
At the end of the endodontic treatment, a new control CBCT scan (5x5 cm and 80 voxels) was performed with Orthophos SL3D for three-dimensional evaluation of the results. The scan was opened in the SICAT ENDO application, and the same steps as described in the planning stage were followed. The analysis confirmed the successful obturation of all four canals (Figure 6).

Final Coronal Restoration
After radiological confirmation of the endodontic treatment, the tooth was prepared for the final coronal restoration. A type V endocrown preparation was chosen for the current case. (10) This type of preparation offers multiple advantages for molars, as it eliminates the need for fiberglass and composite pivot reconstruction, removes the necessity for classic crown preparation, maximizes preservation of remaining hard tissues, and provides proven mechanical resistance and periodontal protection.
The Cerec Primscan system with SW 5.1 was utilized for the digital protocol, which included the following stages: optical impression, model creation, edge delineation of the preparation (Figure 7), preparation design, and milling process (Figures 8A, B). The preparation was milled using the MCXL machine from an Emax LT A2 C14 cube (IvoclarVivadent, Lichtenstein).
Following the milling stage, the crown processing protocol was performed: sprue removal with a ceramic burn, intraoral probe use, finishing and polishing, ultrasonic cleaning in isopropyl alcohol for 1 minute, glazing and make-up, and crystallization in the Programat CS furnace (IvoclarVivadent, Lichtenstein) using the Crystal Glaze program. Subsequently, the final restoration was cleaned with Ivoclean (IvoclarVivadent, Lichtenstein) and conditioned with Prime Bond and Etch (IvoclarVivadent, Lichtenstein) for 60 seconds, washed with water, air-jet dried, and

Figure 6
Control CBCT. Three-dimensional control of root canal obturation using the SICAT application.

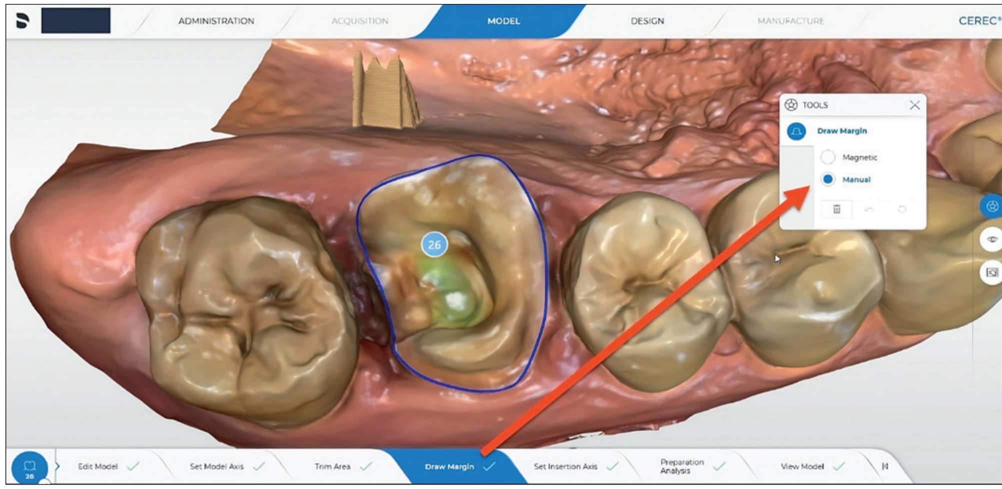


Figure 7
Final restoration using the CEREC system. MODEL stage - outlining the preparation.

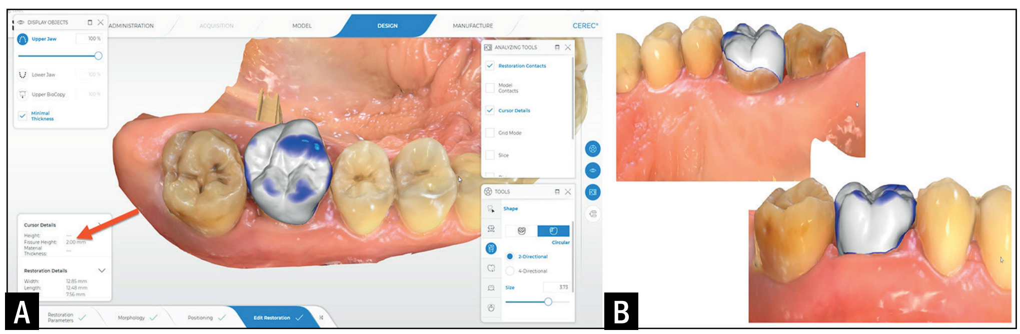


Figure 8
Final restoration using the CEREC system. DESIGN stage. A) Verifying the crown thickness at the Fissure Height. B) The final appearance of the crown project after applying the F.O.C.C. (Fissure - Occlusion - Contour - Contacts) protocol.

treated with Helio Bond adhesive (Ivoclar-Vivadent) (Figure 9A). Without removing the rubber dam isolation, the ceramic crown was cemented using the NX3 kit (Kerr, USA), with a dual core yellow color resin chosen (Figure 9B). At the conclusion of the clinical protocols, the restoration was precisely sealed with correct contact points (Figure 9C). At the four-year follow-up, the tooth was found to be fully functional, with no radiographic lesions or clinical signs and symptoms (Figure 10).

Discussion

The use of digital technologies offers the possibility of a personalized digital workflow for endodontically treated teeth in a single session, bringing numerous benefits. Santos et al. (12), in their case report using a CAD/CAM system, revealed the importance of a good restoration, with margins that integrate excellently and respect magnificent aesthetics. Segundo et al. (13) reported the benefits of a digital workflow for restoration with the CAD/CAM system and how aesthetic results with natural morphology can be achieved.

Radiological examination is an essential component of the diagnostic protocol, planning, and execution of any endodontic treatment. Although periapical radiography has been a source of radiological information for decades, these types of radiographs have clear limitations imposed by their 2D format (14). The additional information provided by CBCT may improve diagnostic accuracy and confidence, especially in teeth with previous endodontic treatment. It is important that patient radiation exposure be kept as low as possible while using a small field of view (15).

The Sicat Endo software (SICAT, Bonn, Germany) allows for 3D analysis of the endodontic system and planning for future treatment. In our daily clinical practice, we found that the mean time required for virtual planning using the Sicat Endo application varied between 5 to 8 minutes, depending on the number of root canals and the complexity of the case. This extra average time is fully justified because the

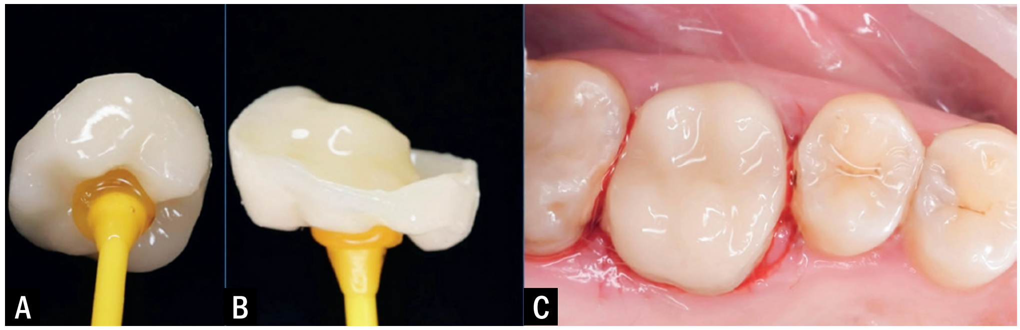


Figure 9A, B. The crown prepared for adhesive cementation. C. The immediate clinical appearance after cementation.

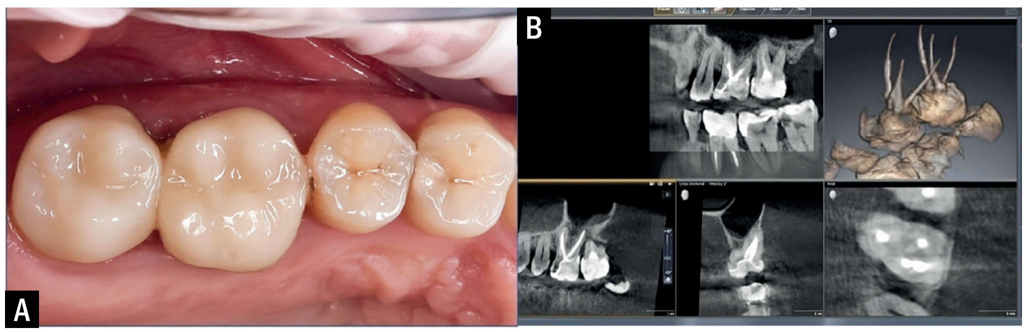


Figure 10 Clinical and radiological appearance at the 4 years follow-up.

duration of actual endodontic treatments has been reduced by 20-30 minutes due to the additional information that this 3D planning provides to the endodontist.

According to the authors, Sicat Endo is the application that "turned on the light in the darkness of the root canals". The use of this program, which can be utilized for any type of CBCT, provides answers for the most challenging endodontic treatments. Access design planning allows for the identification of the area in which to create the access cavity with minimal sacrifice of tooth structure and without additional stress on the instruments. In this manner, it is possible to identify all root canals in a 3D plane, with the possibility of 360-degree visualization. Direct restoration methods (reinforced composite obturation or non-root pivot) do not pose problems from the standpoint of being performed in the same session as the endodontic treatment; they fit seamlessly into the concept of "one-session dentistry."

The situation changes, however, in cases of teeth with extensive coronal destruction that require indirect restorations, which traditionally necessitate collaboration with a dental laboratory and an additional session. In these situations, the CEREC system proves its value by allowing all-ceramic restorations to be made in the same session within an acceptable time frame of 60 to 90 minutes.

More cleaning was planned through a rotary system that allowed for greater enlargement of the root canal and the contaminated walls, as the case had been initiated a year ago by another dentist and was already necrotic. The clinical approach was completed in a single session due to the absence of pain upon percussion; the patient only expressed discomfort due to the loss of coronal dental structure caused by the unfinished endodontic treatment.

The limitation of the current study is a single case. Usually, multiple cases with different diagnostic challenges and longer follow ups may better give idea on the reliability of performed treatment (16-18).

Conclusion

Current case report has shown successful outcomes even after 4 years follow up. The use of these technologies enhances the quality, predictability, and ergonomics of endodontic treatments, eliminating many causes of endodontic treatment failures. The economic benefits are also significant for both the dentist and the patient. With the use of digital workflow and the technology, correct diagnosis, planning, endodontic treatment, and definitive restoration through the CAD/CAM system are achieved. The approach and detailed protocol described in this case report can be easily adopted in a single session in a clinical dental practice using CBCT, Sicat Endo software, and the CAD/CAM system. The advantages of a single visit and immediate reconstruction include a reduction in the potential for microleakage between treatment visits and coronal leakage between appointments.

Clinical Relevance

This case report highlights the successful application of advanced digital technologies in endodontics and restorative dentistry, demonstrating the effective use of CBCT and Sicat Endo software for treatment planning and root canal identification. The one-session endodontic treatment of a maxillary molar, followed by a CAD/CAM-fabricated crown using pressed lithium disilicate material, resulted in a favorable four-year follow-up with no complications. This underscores the importance of integrating modern techniques for enhanced diagnostic accuracy and long-term success, serving as a valuable reference for clinicians in similar cases.

Confict of Interest

Authors deny any conflicts of interest.

Acknowledgements

The current case report has not received any funding.

References

1 Signor B, Blomberg LC, Kopper Poli MP, Nonnenmacher Agustin PA, Rauber MV, Rodrigues GS et al. Root canal retreatment: a retrospective investigation using regression and data mining methods for the prediction of technical quality and periapical healing. J Appl Oral Sci. 2021 Apr 19;29: e20200799.

2 Gillen BM, Looney SW, Gu LS, Loushine BA, Weller RN, Loushine RJ et al. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. J Endod. 2011 Jul;37(7):895-902.

3 Fransson, H. & Dawson, V. (2023) Tooth survival after endodontic treatment, Int Endod J, 56(Suppl. 2), 140–153.

4 Restrepo-Restrepo FA, Cañas-Jiménez SJ, Romero-Albarracín RD, Villa-Machado PA, Pérez-Cano MI, Tobón-Arroyave SI. Prognosis of root canal treatment in teeth with preoperative apical periodontitis: a study with cone-beam computed tomography and digital periapical radiography. Int Endod J. 2019 Nov;52(11):1533-1546.

5 Ng YL, Mann V, Gulabivala K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. Int Endod J. 2010 Mar;43(3):171-89.

6 Bhuva, B, Giovarruscio, M, Rahim, N, Bitter, K, Mannocci, F. The restoration of root filled teeth: a review of the clinical literature. Int Endod J, 54, 509–535, 2021.

7 Kamburoğlu, K.; Sönmez, G.; Koç, C.; Yılmaz, F.; Tunç, O.; Isayev, A. Access Cavity Preparation and Localization of Root Canals Using Guides in 3D-Printed Teeth with Calcified Root Canals: An In Vitro CBCT Study. Diagnostics 2023, 13, 2215.

8 Patel S, Patel R, Foschi F, Mannocci F. The Impact of Different Diagnostic Imaging Modalities on the Evaluation of Root Canal Anatomy and Endodontic Residents' Stress Levels: A Clinical Study. J Endod. 2019 Apr;45(4):406-413.

9 Segato AVK, Piasecki L, Felipe Iparraguirre Nuñovero M, da Silva Nieto UX, Ditzel Westphalen VP, Gambarini G, et al. The Accuracy of a New Cone-beam Computed Tomographic Software in the Preoperative Working Length Determination Ex Vivo. J Endod. 2018; 44: 1024-1029.

10 Tzimas K, Tsiafitsa M, Gerasimou P, Tsitrou E. Endocrown restorations for extensively damaged posterior teeth: clinical performance of three cases. Restor Dent Endod. 2018 Aug 22;43(4): e38.

11 Tong, Z., Zhou, Y., Wei, X. (2020). A Severely Damaged Mandibular First Molar Restoration with CAD/CAM Customized Hybrid Ceramic Post and Core by Direct Intraoral Impression: A Case Report. Clin C Rep.2020; 10:1-5.

12 Santos GC Jr, Boksman LL, Santos MJ. CAD/CAM technology and esthetic dentistry: a case report. Compend Contin Educ Dent. 2013;34(10)

13 Segundo Coelho AR, Saraiva S, de Castro C, Seshua N, Bohner L, Andretti F et al. CAD–CAM natural restorations—Reproducing nature using a digital workflow. J EsthetRestor Dent. 2023; 1-8. doi:10.1111/jerd.13028

14 Patel S, Dawood A, Whaites E, Pitt Ford T. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. Int Endod J. 2009;42(6):447-462

15 Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam computed tomography in Endodontics - a review of the literature. Int Endod J. 2019;52(8):1138-1152.

16 Teja KV, Mustafa M, Esposito L, Iaculli F, Cernera M. Novel non-obturation based concept of regeneration. G Ital Endod. 2024 Jun;38(2).

17 Musso C, Machado R. Extensive external-internal root resorption 22 years after trauma and inadequate endodontic treatment: a case report with 20-years follow-up. G Ital Endod 2023;37(1).

18 Iandolo A, Pantaleo G, Malvano M, Simeone M, Amato M. Nonsurgical management of complex endodontic cases with several periapical lesions: A case series. G Ital Endod 2016;30(2):101-10