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Digi Post - An Impression-Free Novel Technique for Customizing Post and Core

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ABSTRACT:

Endodontic therapy is only successful in the long run if the tooth is suitably rehabilitated. Although countless studies on various types of post and core have been conducted, there is a paucity of studies on customizing post and core with digitalization to eliminate the hassle of impression-making emphasizing the need for the development of strategic techniques.

This article aims to present a novel technique that combines the advantages of pre-fabricated post, in terms of saving clinical time, yet achieving the custom fit of post and core utilizing a digital approach. Further, this study emphasizes two case reports employing the same technique of customizing post and core utilizing Cone Beam Computed Tomography.

A compact run-through for the fabrication of a Digi Post prologues with the preparation of the post space, Standard Tessellation Language (STL) file is attained by converting the Digital Imaging and Communications in Medicine (DICOM) file of a Cone Beam Computed Tomography scan, in which the post can be designed digitally. This innovative technique allows practitioners to perform post-endodontic rehabilitation with greater confidence, simplicity and precision.

Keywords: Esthetics; Computer-aided Designing; Computer-aided Manufacturing; Cone Beam Computed Tomography; Standard Tessellation Language (STL); post and core

1. Introduction:

Endodontically treated teeth frequently require post and core restorations for retention due to structural defects resulting from cavities, large pre-existing restorations and extensive preparation for access¹. Consequences include a significant decrease in their resistance due to the reduction of dentin moisture and compromise of reinforcing structures such as marginal ridges, oblique bridge, and roof of the pulp chamber. Such cases often pose a challenge while choosing an appropriate post-endodontic restorative material^{2,3}.

According to Franklin Weine, most of the endodontically treated teeth often failed subsequently to root canal therapy in arrears to poor post endodontic restoration rather than the primary endodontic cause⁴.

The use of intraradicular posts is indicated for esthetic and functional rehabilitation in endodontically treated teeth that have lost 50% or more of their coronal structure and specifically cast posts where only 25% of the tooth structure is retained. Anterior teeth with Ellis class – 3 fractures often necessitate placement of cast post. Endodontically treated posterior teeth with high occlusal loading, mesial and distal cavities or cervical abrasion, definitely require intraradicular posts for better retention of the core and also to improve the fracture resistance of the tooth⁵.

A wide variety of post systems are available ranging from traditional cast metal posts to newer pre-fabricated fiber and threaded posts. The accessibility, less time consumption for fiber posts along with the available laboratory and clinical evidence authenticates the utilization of fiber posts as an alternative to metal posts. With the advent of prefabricated posts, the use of custom posts has faded away lately owing to the perplexity of its technique.

Despite the constant criticism, cast metallic cores have been used for decades, which is a gold standard treatment regime where the extent of tooth structure loss is significant and maximum retention is required. Custom posts are also very versatile, allow better geometric adaptation to the root canal despite differences in root configurations and angulations, confirm the canal morphology and present satisfactory performance in many long-term clinical studies⁶.

The major technical difficulties in achieving the perfect fit of custom post rely upon various factors including preparation of an ideal post space corresponding to its morphology without undercuts,

accurate impression making of the post space, shrinkage of various materials used for direct or indirect impression technique, voids in material and distortion of the replica. Regardless, the method of fabrication of cast post requires multiple visits.

To the best of our knowledge even with the latest intraoral scanners, post space cannot be read because of the depth reading limitations of light beam throughout the length of the post space leading to fabrication of inaccurate and shorter posts⁷.

In the era of virtual designing and 3D imaging, the fabrication of custom post is still a toilsome task for dental practitioners. Nevertheless, this article emphasizes a breakthrough in the fabrication of custom post using cone-beam computed tomography (CBCT) and Computer-aided designing (CAD-CAM), thus named DIGI POST.

2. Digi Post Technique:

Traditionally, the replica of post space is obtained by a direct technique using a wax pattern or putty silicone impression which is susceptible to voids, inaccuracy is frequently encountered despite having a good armamentarium. An accurate post space impression is an integral prerequisite for fabricating an accurately fitting post.

This proof of concept of fabrication of a Digi Post eliminates the manual error downright and the hassle of impression making. The steps are as follows:

1. After the conventional endodontic treatment and preparation of post space free of undercuts, a segmental limited field of view (FOV) of 4X4 or 5X5 cone-beam computed tomography scan (CBCT) has to be obtained.
2. The data of a cone-beam computed tomography (CBCT) scan is stored as the Digital Imaging and Communications in Medicine (DICOM) data.
3. Three-dimensional modelling software is used to convert the DICOM file into a universally accepted 3D file known as Standard Tessellation Language (STL) which allows further modification and designing in Computer Aided Designing – Computer Aided Manufacturing (CAD-CAM) workflow. STL file is native to the CAD software widely used in dentistry to design any prosthesis and for 3D printing.
4. For this, import the DICOM file into pre-installed open-source 3D modelling software systems DDS Pro (version 2.10.0_2021) and transform it into a 3D model. Export the bone model as a Standard Tessellation Language (STL) file.

- Import the STL file in the inlay module of Computer Aided Designing (CAD) software (DentalCAD 3.0 Galway) and once the tooth preparation margins are marked, the entire post space is detected as "hollow" thereby projecting the positive replica of post space. Further, the coping can be designed and transferred to Computer Aided Manufacturing (CAM), thus attaining the customized post.

With multiplanar reformatting, it is possible to view the dataset containing the tooth structures, obturating material, desired prosthetic reconstruction (core or single unit post and crown) in the axial, coronal, and sagittal planes simultaneously.

Following are two cases demonstrating the Digi post in-vivo which required post endodontic rehabilitation. **CASE REPORT- 1:**

A 28-year-old male patient reported to the Department of conservative dentistry and endodontics with a chief complaint of a broken tooth in the upper front teeth region subsequent to a road traffic accident one month ago. Clinical examination revealed fractured upper right central incisor – #11 involving pulp chamber, non-responsive to pulp vitality tests (Fig 1A). Tooth was not tender on vertical percussion. Clinical findings are confirmed with radiographic evidence arriving at the diagnosis of Ellis class-3 fracture in relation to #11 with pulpal necrosis. Root canal treatment was proposed to the patient, followed by

custom-made Digi Post along with prosthetic rehabilitation and informed consent was obtained.

Isolation was achieved and access opening was done in relation to tooth #11, using access opening bur (Dentsply endo access bur). Working length was established using Root ZX MINI apex locator (J. Morita, Japan) and confirmed on radiovisigraphy using 20 size K file (Mani). Cleaning and shaping were done using a rotary file system (Protaper universal, Dentsply). Canal enlargement was done till F4. 0.9% Normal Saline W/V was used for irrigation, along with 17% EDTA as a chelating agent (Prime Dental, RC Help) for biomechanical preparation. 3% sodium hypochlorite was used as an irrigating agent intermittently. Upon verification of master cone radiograph (Fig 1B), the root canal was obturated with gutta-percha (Dentsply, India) and AH Plus sealer (Dentsply, India) using cold lateral compaction technique. A single visit root canal treatment was performed. The tooth was then temporized with cavit (3M ESPE) (Fig 1C).

In the following visit, after the obturation, gutta-percha removal and post-space preparation were done by mechanical means of gutta-percha removal. Peeso reamer number 3 (Mani) was used for post-space preparation, leaving apical 5 mm of gutta-percha to maintain the apical seal (Fig 1D). After post space preparation, the tooth was prepared for a crown with a crown ferrule, using a flat-end tapered bur (Mani.DIA-Burs.TF-12). A shoulder margin was placed at subgingival level.

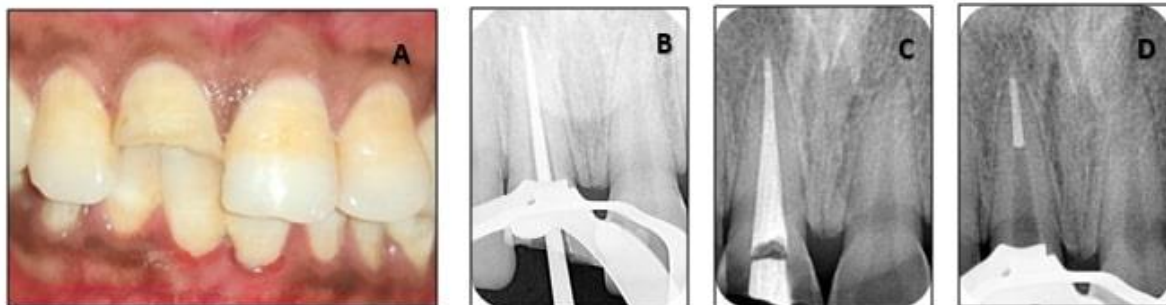


Figure 1: Case-1 Root canal therapy A: Pre-operative clinical photograph showing Ellis class III fracture - #11 B: Master cone radiograph C: obturation radiograph D: Post space preparation radiograph.

A CBCT scan of the maxillary anterior segment was obtained (CARESTREAM 9300) with a Field of View 5X5cm, 90µm resolution (Fig 2). The attained DICOM data was transformed into STL file in DDS Pro (version 2.10.0_2021) (Fig 3) as explained above and imported to CAD (DentalCAD 3.0 Galway) software (Fig 4). In the inlay module of CAD software, the tooth preparation margins were

delineated and the hollow space was detected. The zone indicated in red depicts the post space (Fig 5). Further, the prosthetic crown was also designed by segmenting the adjacent crown of # 21 and superimposing over #11 indicated as yellow (Fig 6). With this superior anatomic contour was produced favouring the esthetic rehabilitation of the tooth.

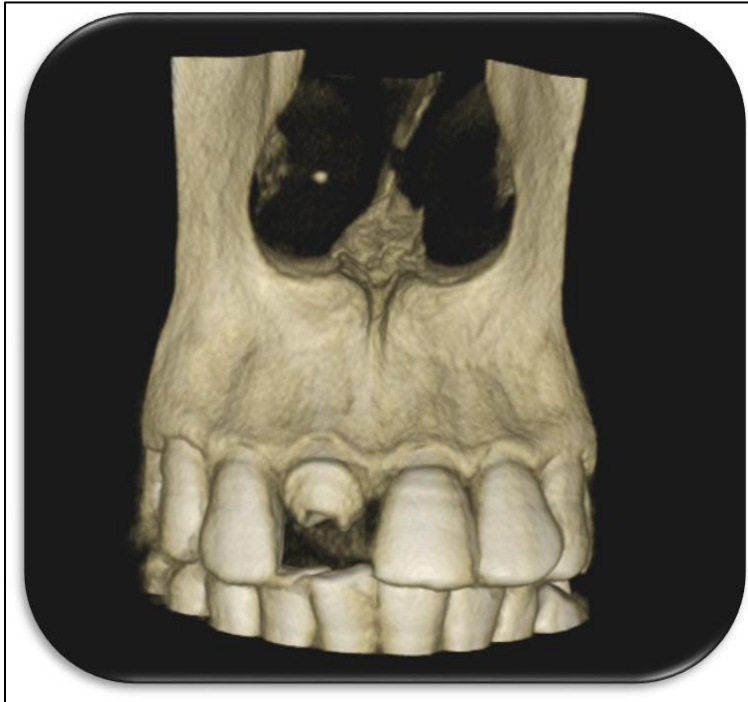


Figure 2: Volumetric rendering image of the DICOM file



Figure 3: Standard tessellation language (STL) file



Figure 4: STL file imported into DentalCAD: A: Anterior view B: Posterior view C: Occlusal view

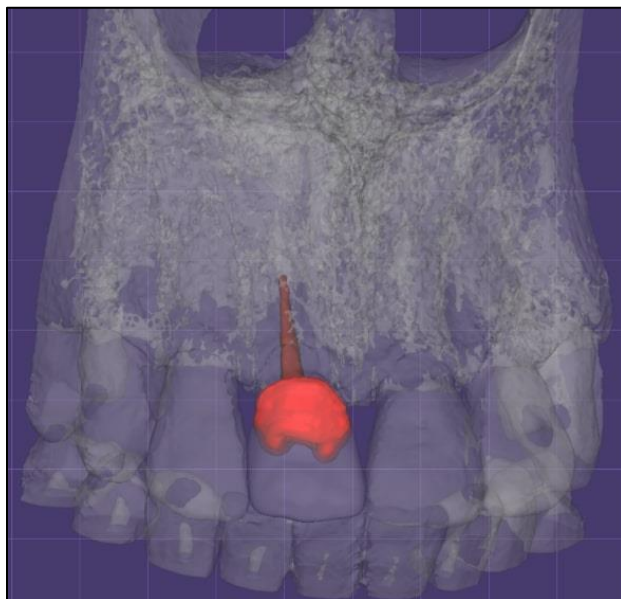


Figure 5: Post space detected as red color

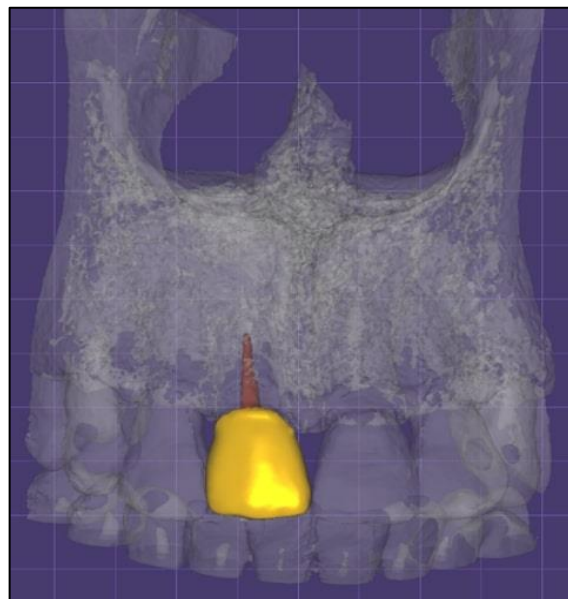


Figure 6: Single unit post and crown design

The design information (Fig 7) was transmitted to a 5-axis milling machine (Arum 5X-200; DoowonID Co) and mill a zirconia block (AlphaZ; DMAX Intl). The milled zirconia post-and-core was later sintered in a furnace (Austromat mSiC; Dekema Dental-Keramikofen GmbH) (Fig 8).

The internal surface of the zirconia post and crown was sandblasted with CoJet™ sand (3M ESPE) 30µm particles and a silane coupling agent (Monobond N, Ivoclar Vivadent) was applied to the internal surface which improves the bonding. The post and core was cemented using self-adhesive resin cement (3M ESPE Relyx Unicem 2 automix) (Fig 9).

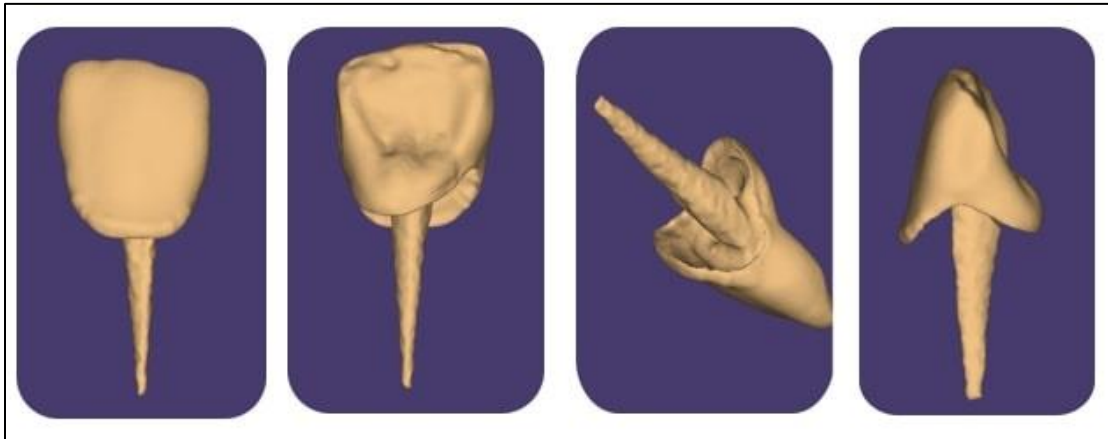


Figure 7: STL images showing anterior, posterior, lateral views



Figure 8: Zirconia prosthesis



Figure 9: Post cementation: A: clinical photograph B: Post cementation radiograph

3. Case Report – 2:

A 35-year-old male patient reported to the Department of Conservative Dentistry and Endodontics with a chief complaint of pain in the lower right back tooth region. On clinical examination, tooth # 46 was grossly carious with fractured distobuccal and distolingual cusps (Fig 10A). Tooth was tender on vertical percussion. Vitality tests gave an exaggerated response. The radiograph revealed dental caries involving

enamel and dentin with concomitant pulpal involvement and mild periodontal ligament widening in the periapical region (Fig 10B). The condition was diagnosed as chronic irreversible pulpitis with apical periodontitis. Root canal treatment was proposed to the patient, followed by Digi post of metal which would later be followed by prosthetic rehabilitation. Informed consent was obtained. Following the root canal therapy, post space was prepared concerning the distal canal (Fig 10 C, D).

Subsequently, the posterior segmental CBCT was obtained, and the Digi post was fabricated using Cobalt – chromium alloy (Fig 11). Post was

cemented and further rehabilitated with a porcelain fused to metal prosthesis (Fig 12).

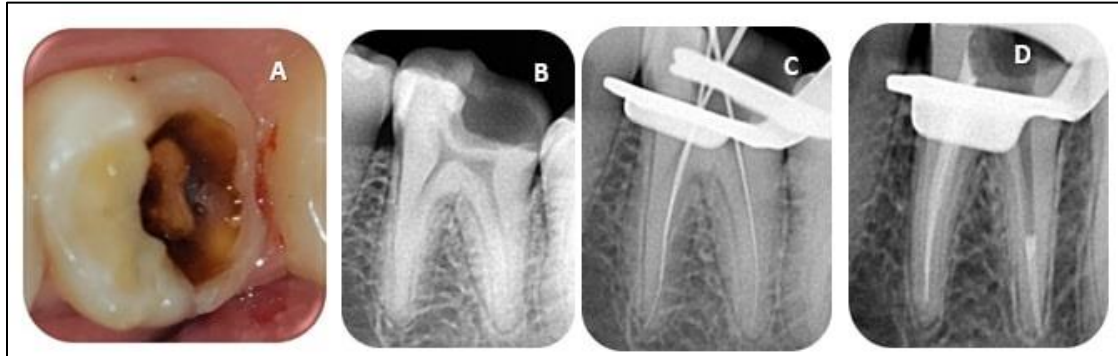


Figure 10: Case- 2: A: Pre-operative clinical photograph #46 B: pre-operative radiograph C: Working length determination D: obturation followed by post space preparation

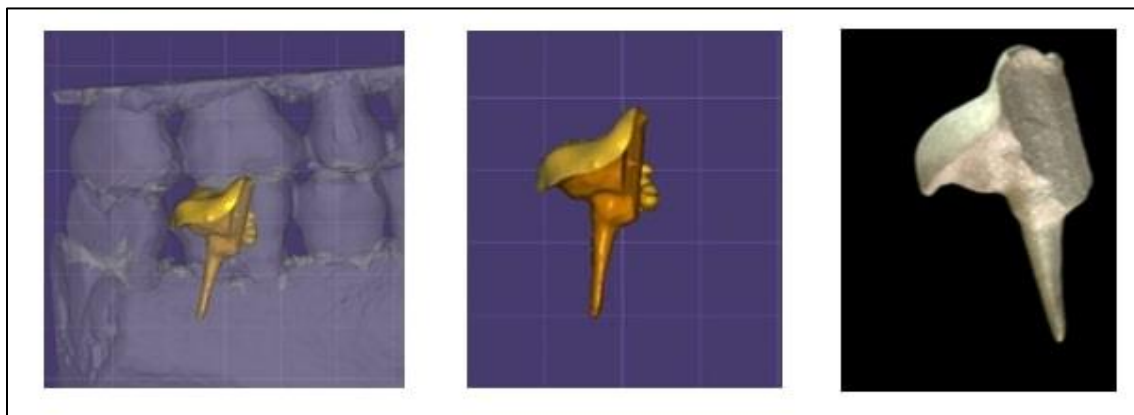


Figure 11: Fabrication of posterior Digi Post

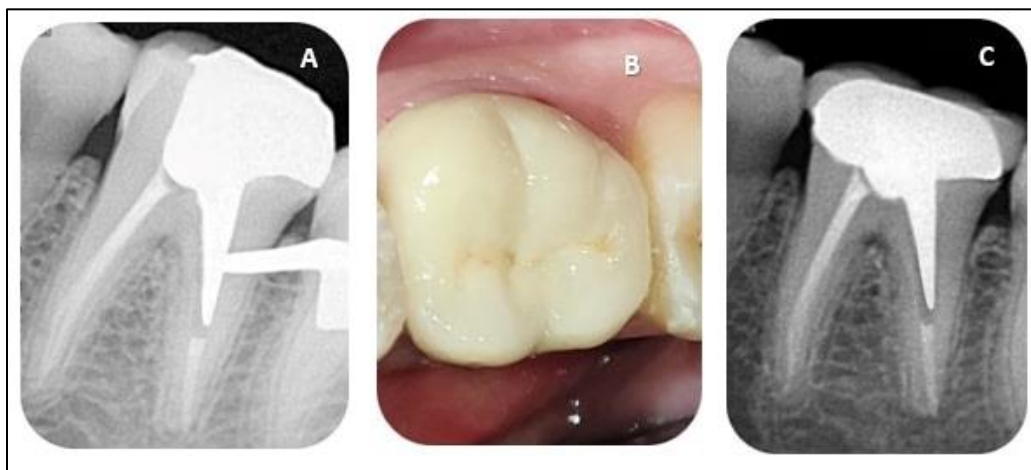


Figure 12: A: Radiograph of cemented Digi post B: post-operative clinical photograph C: post-operative radiograph

4. Discussion:

The success of endodontically treated teeth depends significantly more on the post endodontic restoration rather than the quality of endodontic treatment as suggested by Trope and Ray⁸. Cast posts adapt to the root canal anatomy and can be

used in all types of canal configurations- oval or elliptical. A trivial change in core angulation can be done using cast posts and hence they can be used for amending proclined teeth contrasting other prefabricated posts⁹. According to Gomez Polo et al, custom posts have shown higher survival

rates over 10 years¹⁰. But the drawbacks in the existing state of art include manual errors, material dependent errors, lesser precision, casting errors, unpredictable outcome after fabrication, and multiple visits of the patient.

Pinto et.al studied the efficacy of intraoral scanners to attain the 3D image of post space but has stated that the application of the intraoral scanners for the post-space reading has been proven to be still not reliable to deliver an anatomic post, as there is still depth reading limitations for the narrow root canals. In reality, in this type of channels, it is difficult to reach with the light beam of the IOS to the deepest areas of the post-space, with a consequent incomplete post-space reading⁶.

Lee proposed another technique of fabrication of post where the post space impression was attained with light body impression material. This impression was later subjected to a non reflectant spray and was scanned in a blue light scanner. Further Steriolithographic or Standard Tessellation Language (STL) model is transferred to CAD-CAM. However, the scan data may be erroneous due to the use of a laser scanner, which has higher scanning errors and low repeatability. Furthermore, the buccal vestibule area in the impression may interfere with blue-light projection.¹¹

Cone-beam computed tomography has a wide range of applications in treatment planning in the field of dentistry as in planning surgical guides, implant positioning, prosthetic reconstructions. But after extensive research, we could conclude that Cone-beam computed tomography (CBCT) has not been used to date in endodontics as a feature in post and core planning.

According to the American Association of Endodontists (AAE) and American Association of Oral Medicine and Radiologists (AAOMR) Joint Position Statement (2015), limited field of view (FOV) CBCT is advised for treatment planning when the patient has a substantial benefit that outweighs the potential risks. Limited FOV reciprocates with limited radiation dose as higher spatial resolution and shorter volumes are to be interpreted. The cases presented in this study thus strictly adhered to the "As Low As Reasonably Achievable" (ALARA) principle and used a limited field of view (FOV) of 5X5 judiciously¹².

After conducting an extensive literature search, studies comparing the accuracy of CBCT and intraoral scanners pertaining to the aspect of their resolution have not been performed in the field of endodontics. However, Kolsuz et. al conducted a

study comparing the accuracy of Cone-beam computed tomography with different voxel sizes and Intraoral scanners for detecting periodontal defects concluding that smaller field of view (FOV) scan has better diagnostic accuracy, spatial resolution and highest sensitivity¹³.

Traditional approaches for fabricating custom post and core have a significant risk of distortion, are time-consuming (almost 4-5 appointments), and clinicians feel it tedious to attempt leading to compromised treatment.

The advantages which outstand the innovation of Digi Post include the lesser chairside time which saves the same for patients and clinician with lesser visits, thus non-dexterous to patients and clinician. With the application of artificial intelligence, manual and material-dependent errors while making impressions, shrinkage of impression material due to inherent stresses, transportation of the impression to the laboratory, distortions are eliminated thus achieving higher accuracy, making the process hands-free.

In case 1 broken tooth #11 has been rehabilitated with a single unit digi post and crown, thus reducing the number of appointments to two. This advantage of fabricating a single unit takes the digi post up a notch, unlike traditional custom post and core. Zirconia was opted as the choice of material considering esthetics as the primary concern. The zirconia post was sandblasted with CoJet™ sand (3M ESPE) 30µm particles and a silane coupling agent (Monobond N, Ivoclar Vivadent). Sandblasting treatment improves the surface roughness and increases the surface area allowing the oxides to react with the resin cement¹⁴⁻¹⁶. Silane coupling agent forms a chemical bond between the zirconium oxides and the monomers in the resin cement^{17,18}. Studies have shown that pre-cementation sandblasting and silane treatment when coupled with dual-cure resin cement for luting improves the retention of zirconia post and core by enhancing its shear bond strength^{19,20}.

Posterior teeth often pose a greater challenge when a custom post is necessary. To overcome this, clinicians often restore the teeth with fibre posts which require greater removal of radicular dentin in order to accustom the pre-fabricated metal or pre-fabricated fibre posts. Digi Post offers a promising approach for fabricating a custom post even in posterior teeth (Case report- 2) which are grossly mutilated.

Cone-beam computed tomography acquisition for a patient with a prosthesis could be troublesome due

to the production of metal artifacts but with the concept of acquiring multiple basis images which is capturing greater number of images, information available for image reconstruction is exponentially high resulting in lesser artifacts ²¹. The use of Cone-beam computed tomography requires judicious decision-making pertaining to the clinical situation and treatment plan.

Further research is necessary to compare and evaluate the accuracy of CBCT and intraoral scanners in the field of post endodontic restorations. We further recommend the upgradation of CAD-CAM software with a post and core module implementation, so as to establish a digital work flow in the stream of post endodontic restorations as well.

5. Conclusion:

As endodontists, we work on achieving perfection at its finest and blending the rehabilitating prosthesis inconspicuously without compromising the tooth harmony. To conclude, Digi Post could be a quantum leap manifestation that is made to take endodontics a step further towards digitization. This innovative technique allows

practitioners to perform post endodontic rehabilitation with greater confidence, simplicity and precision.

6. Key Highlight Points:

- Intraoral scanners are still not reliable for post space impression.
- Cone beam computed tomography (CBCT) combined with Computer aided designing and Manufacturing (CAD-CAM) makes custom post fabrication nearly impression free.
- With the aid of digitalization, supreme accuracy, and precision can be attained.
- Digi post offers lesser chair-side time and eliminates manual, material-dependent errors.

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Conflicts of Interest: Nil

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