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Digital Dentistry and its Role in Fabrication of Post and Core

Research Article

Gayatri Rajpurohit[1], Dr. Manish Ranjan[2*], Dr. Sowmya K[3]

[1] Undergraduate Student, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 600077, Tamil Nadu, India.
[2] Associate Professor, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 600077, Tamil Nadu, India.
[3] Senior Lecturer, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 600077, Tamil Nadu, India.

Abstract

Introduction: In recent times there has been an increase in demand for restorative treatment along with it comes advancement in automated dental technology which is easily accessible to dental companies. The new era in the field of dentistry revolves around computer aided milling and additive manufacturing of restorative materials which not only reduce work timing but also are almost defect free with lower incidence of errors and repeats. The present article stresses on the advancement in fabricating post and core used for endodontically treated teeth.
Purpose: Digital dentistry has been developed to increase workflow precision and to accelerate the process of production. The purpose of this article was to assess the superiority among CAD-CAM and additive manufacturing by highly precise cast and post which will be more accurate , less time consuming and easy for the operator.
Conclusion: The use of Digital dentistry represents an opportunity for the clinician as it speeds up the production of an anatomical post and core restorations.

Keywords: Digital Dentistry; 3D Printing; Cad/Cam Post; Endodontically Treated Tooth.

Introduction

Previously our team had a rich experience in working on various research projects across multiple disciplines [1-15]. Now the growing trend in this area motivated us to pursue this project.

Post and core restoration is a type of restoration which is recommended for endodontically treated teeth when a restoration fulfilling the tooth's masticatory and esthetic functions is not possible using the coronal remaining tissue. Endodontically treated teeth are well known to be more susceptible to fracture, the major scientific backing accounting to the loss of hard tissues coming from the sum of an initial carious pathology, the endodontic access cavity, instrumentation and finally, for a minimal part, for the biochemical and structural changes in non-vital dentin . On the other hand even saliva as it plays an important role in microbial oral flora regulation [16].

After endodontic treatment, a proper restorative technique is necessary to ensure coronal seal and protection of residual dental structure . Teeth which have lost two or more walls need to be restored with endodontic posts for final restoration which not just increases retention and stability but also affect the outcome of the treatment [16, 17].

Several materials have been proposed to fabricate posts; metallic posts belong to I and II generations, fiber, ceramic and zirconium oxide are III and IV generations [16-18].

In comparison to rigid metal and/or ceramic posts, fiber posts have better biomechanical behavior because their physical properties are closer to natural dentin allowing for a better distribution of occlusal forces and reducing substantially, if compared with harder materials,the risk of vertical root fracture. Moreover, posts

***Corresponding Author**:
Dr. Manish Ranjan,
Associate Professor, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai 600077, Tamil Nadu, India.
Tel: +91- 9543445029
E-mail: manish@saveetha.com

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can be distinguished into prefabricated and customized, which are manufactured by lost wax technique or CAD-CAM. Several metal alloys have been used to manufacture cast posts such as cobalt–chromium [Co-Cr], nickel–chromium [Ni-Cr], and gold alloys due to their hardness, price, and tensile strength. However as an alternate, fiber posts are strong but have significantly less stiffness and strength than metal posts.The use of custom prepared posts [or post and cores] allows for a very thin layer of cementing resin thus providing a good way to reduce drastically polymerization stresses and gaps or voids formation in the adhesive interface [16-20].

The modern idea of a customized post and core calls for conservation of root dentin with minimal or no preparation of a post-space thus resulting in thicker dentin walls and increased resistance to root fracture and ease of core restoration.In the last decade, computer supported technologies for building removable and fixed partial prosthesis, such as computer aided design [CAD] and computer aided manufacturing [CAM], have become very popular. These technologies are used in dentistry to fabricate a variety of prostheses ranging from crowns to long-span fixed partial dentures and removable partial dentures. CAD/CAM milling and direct metal laser sintering [DMLS] are used to fabricate Co-Cr products and these two techniques have decreased cost, eliminated manufacturing [time-consuming processing] and human errors [distortion of wax patterns and irregularities in the cast metal], and improved the accuracy of fitting using the traditional casting technique. Intraoral digital scanners with CAD/CAM and rapid prototyping have been popular to fabricate post and core with accelerated techniques, whereas DMLS is a popular additive metal fabrication technology that employs a high power ytterbium [Yb]-fiber optic laser to melt the metal powder, which is then built up layer by layer to a 10–30 mm thickness . DMLS technology offers highly accurate construction of fixed partial dentures with fine marginal adaptation and advanced mechanical properties. While studies are directed at marginal and internal fit of metal ceramic restorations fabricated with CAD/CAM and DMLS , In the past years, several attempts to customize prefabricated posts have been done by subtractive or additive ways. this "hand-made" approach could be surpassed by CAD-CAM technology. Aim of this paper is to find out [21].

This study is a review of literature and a qualitative study [Pereira et al., 2018]. Articles and other literary sources with interrelation to CAD-CAM and endodontic posts were surveyed through research in Pubmed, Scielo, Scopus, Lilacs and Google Scholar databases. The keywords:3D printed post, CAD CAM post, Endodontically treated teeth, Root canal treated teeth were used to do the survey. More than 74 articles were found, and after reading the abstract, 11 were selected, 8 after reading selected for review. Our institution is passionate about high quality evidence based research and has excelled in various fields [5], [22-31].

CAD/CAM Cast and Post:

Custom fabricated post-and-cores, which have historically been made of casting metal, are among the earliest post systems that have been used to successfully restore endodontically treated teeth. These custom post-and-cores remain an indispensable treatment modality in modern dental practice, are popular among practicing dentists, and have been considered the gold standard to restore structurally compromised endodontically treated teeth but with the development and wide-spread use of computer-aided design/computer-assisted manufacturing [CAD/CAM] systems in dental clinics and laboratories custom post-and-core can now be fabricated not only from cast alloys but also from many contemporary [CAD/CAM] dental materials such as zirconia, nano ceramic resin composite, fiber-reinforced composite and high-density polymers. The fully digital technique uses a digital scan and scan posts that are compatible with specific drills that shape the canals; this is followed by digital design using specialized design software modules and milling. Studies are directed at marginal and internal fit, fracture resistance of post-cores fabricated with CAD/CAM etc [32, 33].

Customized metal post–cores have been successfully used to restore endodontically treated teeth due to their excellent physical properties. However, because of the high elastic modulus, there is a high concentration of stress in the surrounding radicular dentin, leading to root fracture. In addition, a metal post–core has some disadvantages such as microleakage, corrosion, and an esthetic drawback as a result of metal color reflection on all-ceramic restorations [32].

A zirconia post and core fabricated by using computer-aided design/computer-aided manufacturing [CAD/CAM] technology has been used to restore anterior endodontically treated teeth .However, the high modulus of elasticity [200 MPa] of zirconia posts leads to the transfer of stress to the less rigid dentin and causes fracture of the root. The polymer-infiltrated ceramic network [PICN] Vita Enamic [Vident, Brea, CA, USA] is currently available to be milled as a post and core using CAD/CAM technology. This material has high flexural strength, elasticity, and physical properties similar to those of natural teeth to overcome the brittleness of ceramic that causes wearing on antagonist natural teeth. This material combines the positive characteristics of ceramic materials with those of composite and can be used with CAD/CAM technology [34].

The advantage of using CAD/CAM technology to fabricate the post and core is that there is improved adaptation with minimum tooth structure reduction and the ability to overcome the errors of conventional fabrication methods such as impression, waxing, and casting errors.

A significantly higher push-out bond strength of the CAD/CAM posts compared with the prefabricated posts highlights the fact that anatomically adapted posts significantly increases the retentive strength of the post and cores in comparison with prefabricated posts. The development of tooth-colored post systems occurred with increased esthetic demands as well as possible problems that result from the corrosion of posts made from non-noble alloys [35, 36].

Custom-fit posts and cores ensure a better fit in the canal and an increase in the pressure during cementation, which may result in better contact between the cement/post assembly and the dentin. Therefore, a thinner layer of cement reduces the polymerization shrinkage, leading to higher bond strength, which might explain the high bond strength observed in the apical third of the prefabricated groups in comparison with the coronal third. On the other hand, the decreased bond strength in the apical region of the roots in the CAD/CAM groups may be explained by a lower

polymerization in depth and the high C-factor due to the unfavorable cavity configuration of the post space. This is in accordance with several in vitro studies that evaluated the effect of post relining on push out bond strength and also concluded to a decreased bond strength values in the apical region of the root canal due to a lower polymerization of the composite [37].

The digital technique allows us to convert the concave surface of the root canal into the convex surface of the post, and realize an anatomical post and core that improves the biomechanics of the endodontically treated tooth reducing the possibility of root fractures [18].

In one of the studies it was concluded that Better CAD/CAM post-and-core is expected from direct pattern scanning than with impression scanning. But the limitations of this technique include the initial learning curve, the additional steps, the use of multiple types of software, and the sensitivity of the technique for scanning small objects such as a post-and core pattern.

In another study fracture resistance and failure modes of root-filled teeth restored with three different computer-aided design/computer-aided manufacturing [CAD/CAM]-fabricated post and core assemblies were measured..Result of that study shows that metal and zirconia samples showed an unfavorable fracture, while few PICN samples exhibited a favorable fracture. PICN material can be used in the fabrication of post and core assemblies using CAD/CAM [38].

Customized post-and-cores of PEEK and nano-ceramic composites exhibited good mechanical performance. Their fracture resistance was comparable to that observed for fiberglass customized posts, yet lower than that for cast metal posts. For PEEK post-and cores,In particular [39].

The computer-aided design/computer-aided manufacturing [CAD/CAM] methods described in the literature for building a post and core involve taking the impression of the post space and adjacent teeth, casting in type IV high-strength die stone, and fabricating a wax pattern. Another method involves scanning the anatomy of the canal utilizing auto polymerized acrylic resin on a plastic post [40].

In one of the studies the marginal adaptation and internal fit of milled fiber post and cores using different scanning methods were evaluated. Three different methods of scanning were used .An intraoral scanner [IOS] [Trios 3; 3Shape] to directly digitalize the post space [Group T] and a laboratory scanner to indirectly digitalize the resin pattern [Group RP] and the silicone impression [Group S] of the post space. All the specimens were examined using an optical microscope for the measurement of the vertical marginal discrepancy , and five in each group were scanned using microcomputed tomography for the assessment of the , the internal fit at the corner , post apex , and at four horizontal cross-sections [CS1-4] inside the canal. Better adaptation was achieved with a complete digital workflow. Scanning the resin pattern or the silicone impression introduced more variables in the digital process or milling of a one-piece fiber post and core [41].

Compared to conventional impression methods, digital intraoral impression systems show higher local deviation of the dental arch yet they provide excellent clinical results within their indications applying the correct scanning technique [42].

Customization of post-and-cores using computer-aided design and computer-aided manufacturing [CAD-CAM] requires the scanning of a pattern and the subsequent digital design. This technique describes a method of fabricating a CAD-CAM-customized post-and-core designed from a scanned polyvinyl siloxane impression and milled from a nanoparticle/nanocluster-filled resin block. The polyvinyl siloxane impression allowed a faster and more efficient customization of the CAD-CAM post-and-core than a conventional acrylic resin pattern. The properties of the nanoparticle/nanocluster filled resin block make the material suitable for chairside CAD-CAM post-and-core fabrication [43].

In another study, a custom-made post and core was designed using CAD/CAM technology's CEREC system without a stone cast or wax pattern. A simultaneous two-stage impression technique for post space and adjacent teeth was performed using vinyl polysiloxane, and a 3D CEREC Bluecam camera was used for scanning. Data were processed with Inlab SW 4.2 software, facilitating the development of a three-dimensional digital model of the impression through specific parameters. The CEREC system proved to be a reliable method for generating the design of a custom-made post and core without a stone cast or wax pattern [44].

In one more study ,the effect of milling custom fit anatomical posts and cores from fiber reinforced composite and high-density polymer blocks using CAD/CAM technology was investigated . Bond strength to root canal dentin compared with prefabricated fiber posts, and the influence of thermal cycling on the push out bond strength of the tested materials was evaluated.

Push-out bond strength was significantly higher [$p < 0.001$] in the CAD/CAM post groups than in the groups with prefabricated posts regardless of the post material, while aging of the teeth did not significantly affect the push-out strength [$p = 0.536$]. Failures were adhesive between cement and dentin for all groups except for AMC, where adhesive failure between the cement and the post was also observed. The CAD/CAM manufacturing technique was proved to ameliorate the retention of the post and cores in the root canal. Thermal cycling did not affect the bond strength of the tested groups [42, 45].

In a study over the fracture resistance of Co-Cr postcores fabricated with 3 different techniques: traditional casting , computer-aided designing-manufacturing and direct metal laser sintering were analysed for their differences . The study concluded with the results that no difference is observed with the fracture resistance of Co-Cr posts fabricated by traditional casting and direct metal laser sintering systems. While on the other hand posts fabricated by CAD CAM techniques showed higher fracture resistance values. Co-Cr metal posts fabricated by CAD CAM and direct metal laser sintering could be an alternative to traditional casting processing in daily clinical application [19].

Conclusion

Several studies and clinical reports suggested that post and core fabricated by subtractive and additive manufacturing methods are considered superior to conventionally fabricated post and core due to its favorable mechanical, chemical and physical proper-

ties.Within the limitations of this literature review, it is concluded that metal posts fabricated by CAD CAM and Direct Metal Laser Sintering systems showed similar or higher fracture resistance strength within an acceptable range as compared to traditional casting.After reading, analyzing and interpreting the scientific studies surveyed, it was possible to verify that the CAD-CAM endodontic posts have shown satisfactory results, although there are few specific studies, and there is a need to laboratorial and clinical studies using these technologies, such as three points bending test, clinical longevity and shear bond strength.

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