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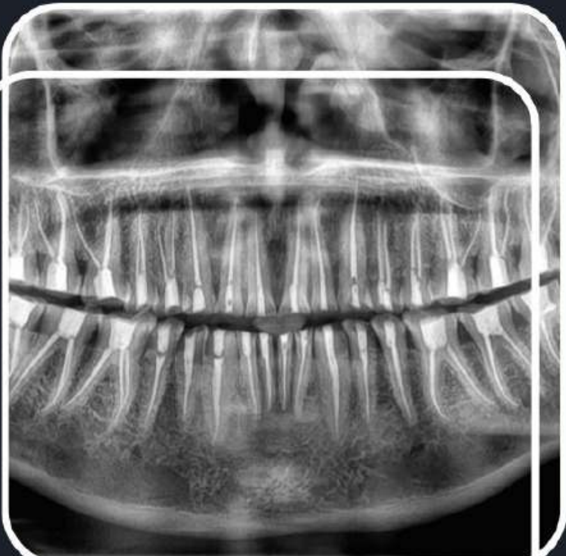

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JRDE

Journal of Restorative Dentistry and Endodontics

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Journal of Restorative Dentistry & Endodontics

The scope of the journal is to publish manuscripts in the specialty of conservative dentistry & endodontics and aims to influence the practice of dentistry at clinical, research and ethical level on national and international basis.

The Journal strives to publish high quality research papers that disseminate scientific and clinical knowledge. Original scientific articles, Case report and Review articles are published in the areas of applied materials science, bioengineering, epidemiology and social science relevant to conservative dentistry & endodontics.

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Journal of Restorative Dentistry and Endodontics

Address: Dr. Kiran Kumar
Professor and HOD
Department of Conservative dentistry and Endodontics
GDCR Fort, Bengaluru, 560002
www.acekarnataka.in
Email id: acekjournal@gmail.com

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EDITORS DESK

Greetings!

On behalf of the Editorial Team, it gives me great pleasure to extend a warm welcome to all our esteemed readers to this year's issue of the journal. We take this opportunity to express our sincere gratitude to our dedicated authors, reviewers, and editorial board members whose continuous support and scholarly contributions have been instrumental in upholding the quality and integrity of our publication.

The journal continues to serve as a dynamic platform for the exchange of ideas, innovations, and research across the diverse specialities of our field. Each issue reflects the commitment of the scientific community to advance knowledge through rigorous, evidence-based inquiry and peer-reviewed scholarship.

This year, we are particularly delighted to present a collection of articles that highlight recent developments, emerging trends, shaping the future of our discipline. We hope that these contributions will inspire further dialogue, collaboration, and innovation among researchers, clinicians, and academicians.

We remain committed to maintaining the highest editorial standards and to providing our readers with content that is not only informative and relevant but also thought-provoking and impactful.

We extend our heartfelt appreciation to all contributors for their invaluable efforts and to our readers for their continued encouragement and engagement. We look forward to your active participation and feedback as we strive to make each issue a step forward in scientific excellence.

Dr. Veena S Pai

Editor-in-Chief

Digital Smile Design: A Decade of Innovation in Aesthetic Dentistry

Dr. Rukmini Amarnath[1], Dr. Rashmi G Shetty[2], Dr. B S Keshava Prasad[3], Dr. Vanamala N[4]

1-Post graduate student, 2- Reader, 3 Professor and HOD, 4- Reader

Address for correspondence: Dr. Rukmini Amarnath
Department of conservative dentistry and endodontics, DAPMRV DENTAL COLLEGE
Bengaluru, CA-37, 24th Main Rd, ITI Layout, 1st Phase, J. P. Nagar, Bengaluru, Karnataka 560078
Email id- rukminiamarnath331@gmail.com

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ABSTRACT

Digital Smile Design (DSD) has transformed aesthetic dentistry by integrating digital technologies into smile analysis, treatment planning, and patient communication. This review explores the evolution of DSD over the past decade, highlighting technological advancements, clinical applications, patient satisfaction, and ethical considerations. Drawing from recent literature, we examine how DSD has enhanced precision, predictability, and patient engagement in dental treatments.

KEYWORDS:

INTRODUCTION

The pursuit of an ideal smile has long been a central focus in aesthetic dentistry. A beautiful smile can significantly affect self-esteem, social interactions, and overall psychological well- being. Traditional aesthetic dental treatments often relied on manual techniques and subjective assessments, leading to inconsistencies in outcomes and limited reproducibility. As patients increasingly seek high-quality, predictable results, the dental profession has turned to digital solutions to meet these demands.

Digital Smile Design (DSD) emerged as a transformative approach that combines art and science. By employing digital tools, clinicians can now perform a comprehensive facial and dental analysis to design smiles that harmonize with the patient's facial features and personal expectations [1]. The emphasis on patient-centric care and visual communication has propelled DSD to the forefront of modern dental aesthetics.

Evolution of Digital Smile Design

The concept of DSD was pioneered by Dr. Christian Coachman in the early 2010s, laying the foundation for a new paradigm in aesthetic dentistry. Initially, the system revolved around the use of 2D photographs, facial reference [3]. lines, and digital overlays to plan restorations. These visual tools enabled the dentist and patient to co-design the ideal smile [2].

Over the last decade, DSD has rapidly evolved with technological innovations. The integration of 3D imaging, facial scanning, intraoral scanners, and digital workflows has refined diagnostic capabilities and increased the precision of treatment planning. Platforms like DSD App and SmileFy now offer complete digital ecosystems that unify photography, videography, facial analysis, and restorative design in one platform.

These systems not only facilitate more accurate planning but also improve collaboration between interdisciplinary teams, including orthodontists, periodontists, and laboratory technicians. Furthermore, the evolution from static image analysis to dynamic video documentation has introduced a new layer of realism in the treatment process.

TECHNOLOGICAL ADVANCEMENTS IN DSD

1.1 Artificial Intelligence Integration

The adoption of artificial intelligence (AI) in DSD platforms has led to significant improvements in treatment planning efficiency. AI algorithms are capable of analyzing a large dataset of facial features, dental anatomy, and smile dynamics to suggest optimal restorative designs that conform to esthetic principles.

AI also aids in automating smile recognition and segmentation, allowing the system to accurately determine midlines, smile arcs, gingival zeniths, and incisal edges without manual input. This advancement minimizes human error, shortens treatment planning time, and enables more standardized results [4].

1.2 Augmented Reality and Virtual Simulations

Augmented Reality (AR) has emerged as a powerful tool in enhancing the visualization of treatment outcomes. Using AR glasses or mobile applications, clinicians can project digital smile designs directly onto a patient's face in real-time. This immersive experience fosters a greater level of patient understanding and engagement, as they can instantly preview their new smile from different angles and lighting conditions [5].

Virtual simulations also enable detailed aesthetic evaluations and precise mock-ups, reducing the risk of patient dissatisfaction. These simulations are useful not only for consultations but also for documentation and medico-legal purposes.

1.3 3D Printing and CAD/CAM Integration

Another milestone in the DSD workflow is the integration with Computer-Aided Design and Manufacturing (CAD/CAM) systems and 3D printing technologies. Once the digital plan is finalized, the data can be used to fabricate mock-ups, wax-ups, provisional restorations, or final prostheses with micron-level accuracy [6].

This level of precision significantly reduces chair time, optimizes fit, and enhances the longevity of restorations. Moreover, 3D printing allows for the production of physical smile trial models, enabling patients to physically try on their future smile before any irreversible procedures.

1. CLINICAL APPLICATIONS OF DSD

1.1 Comprehensive Smile Analysis

A cornerstone of DSD is its comprehensive approach to smile evaluation. The analysis includes both static and dynamic assessments of facial features, such as interpupillary line, midline alignment, incisal display, smile arc, buccal corridor space, and lip mobility. DSD also considers phonetics and personality traits to customize smiles that reflect the patient's identity [7].

This level of detail is crucial for ensuring that the final restorations are not only functional but also naturally aesthetic and emotionally appealing

1.2 Interdisciplinary Treatment Planning

DSD facilitates communication between dental specialists by offering a shared visual language. For complex cases that require orthodontics, implantology, or periodontal intervention, DSD acts as a central planning tool that aligns all aspects of treatment toward a unified esthetic goal [8].

This interdisciplinary approach not only improves outcomes but also reduces treatment time, enhances workflow efficiency, and fosters mutual understanding among practitioners.

1.3 Patient Communication and Consent

One of the most transformative aspects of DSD is its impact on patient communication. By using digital mock-ups and videos, patients can visualize the treatment process and final results in a tangible way. This visual engagement helps patients better understand the rationale behind clinical decisions and allows them to express their preferences more clearly [9].

Patients who participate in the co-design process are more likely to adhere to treatment and express greater satisfaction post-treatment. Additionally, visual consent obtained through these tools offers medico-legal advantages by documenting that patients were fully informed.

2. PATIENT SATISFACTION AND OUTCOMES

Numerous studies over the past decade have emphasized the role of DSD in increasing patient satisfaction. Patients report higher levels of confidence, trust in the dentist, and emotional readiness when presented with digital previews and simulations [10]. In fact, many patients have cited the visual mock-up as the key decision-making factor for accepting treatment plans.

From a clinical standpoint, outcomes have also improved. Because DSD allows for more accurate assessments and guided preparations, dentists achieve better marginal integrity, occlusal harmony, and overall aesthetic integration. Treatment outcomes are more predictable, and cases involving porcelain veneers, crowns, and implants show improved long-term performance [11].

DSD also supports post-treatment evaluations by enabling before-and-after comparisons that can be used for patient education, marketing, or professional development.

3. ETHICAL CONSIDERATIONS AND CHALLENGES

3.1 Data Privacy and Security

As with all digital health technologies, DSD platforms handle sensitive patient information, including high-resolution facial images, intraoral scans, and medical histories. This raises concerns about data security and the risk of unauthorized access or data breaches [12].

Clinicians must ensure compliance with regulations like the GDPR and HIPAA, employ encrypted data transmission protocols, and educate staff on digital ethics and cybersecurity practices.

3.2 Managing Patient Expectations

While DSD offers remarkably accurate simulations, there remains the risk of overpromising. Patients may view digitally enhanced images as guaranteed results, not understanding that biological, technical, and procedural factors can alter the final outcome [13]. Dentists must take care to emphasize that mock-ups are predictive tools, not absolute certainties.

Clear documentation, signed agreements, and a thorough explanation of possible complications or compromises are essential in managing expectations.

3.3 Accessibility and Cost

The cost of DSD technology, software licenses, and compatible hardware can be a barrier to adoption, especially in developing regions. Moreover, mastering DSD workflows requires training, which may not be readily available or affordable to all practitioners [14].

Nevertheless, as the technology matures and becomes more widespread, there are growing efforts to develop open-source alternatives and offer remote training courses to make DSD more inclusive.

4. FUTURE PERSPECTIVES

Looking ahead, the future of DSD is poised to benefit from exponential technological advancements. AI will likely evolve to deliver even more personalized designs by learning from databases of patient preferences, facial expressions, and smile outcomes. Machine learning may further automate diagnostic steps and propose evidence-based treatment plans.

Tele-dentistry platforms could integrate DSD, allowing patients to initiate smile assessments from their own devices. This could expand access to aesthetic dental consultations, particularly in remote or underserved communities

Other innovations, such as digital twin technology and emotion-aware smile design algorithms, are being explored to simulate emotional expressions and improve the realism of treatment outcomes.

CONCLUSION

Digital Smile Design has revolutionized the landscape of aesthetic dentistry by merging digital technology with artistry and clinical precision. Over the last decade, DSD has evolved from a 2D visualization tool into a comprehensive digital ecosystem that empowers clinicians and engages patients in meaningful ways.

Through AI integration, AR visualization, and 3D printing capabilities, DSD has improved the accuracy, predictability, and patient satisfaction associated with smile rehabilitation.
While challenges such as cost, training, and ethical considerations remain, the trajectory of innovation and increasing accessibility suggests a bright future.

As aesthetic expectations rise and patients demand personalized care, the adoption of DSD will become not just an advantage, but a necessity in delivering high-quality dental care.

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REVIEW ARTICLE

Bridging Biology and Clinical Practice: Pulpotomy in Mature Teeth

Dr. Karthik Shetty[1], Dr. Vighnesh Mohandas[2], Dr. Heta Vaghasia[3], Dr. Emshal Malik[4]

1- Professor and HOD ,2,3 4- Post graduate student

Address for correspondence: Dr. Karthik Shetty, professor and HOD, Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences Mangalore, Manipal Academy of Higher Education, Karnataka, Manipal, 576104, India. Contact no: +91 9900008040, Email id- karthik.shetty@manipal.edu

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ABSTRACT

Pulpotomy, once primarily reserved for primary and immature permanent teeth, is now being recognized as a viable treatment option for mature permanent teeth with carious pulp exposures, even in cases clinically diagnosed with irreversible pulpitis. This shift is driven by emerging evidence in pulp biology, which reveals that inflammation is frequently confined to the coronal pulp, leaving the radicular pulp tissue capable of healing and regeneration. Histological findings, coupled with the demonstrated potential of mesenchymal stem cells and pulp fibroblasts to initiate repair, support the rationale for vital pulp therapy (VPT) as a conservative alternative to traditional root canal treatment (RCT). Contemporary pulpotomy techniques, including partial, full, miniature, and deep pulpotomy, have shown favourable clinical outcomes when paired with proper case selection, effective haemostasis, aseptic protocols, and durable coronal sealing. The use of bioceramic materials such as mineral trioxide aggregate (MTA), Biodentine, and calcium-enriched mixture (CEM) has further improved the prognosis due to their superior sealing ability, bioactivity, and biocompatibility compared to traditional agents like calcium hydroxide.

In addition to procedural advancements, current research into pulpal biomarkers particularly matrix metalloproteinase-9 (MMP-9) suggests the potential for future chairside tools that may enhance diagnostic accuracy and clinical decision-making. Pulpotomy not only preserves the structural and biological integrity of the tooth but also offers practical advantages, including reduced postoperative discomfort, shorter treatment time, and cost-effectiveness. As evidence continues to accumulate, pulpotomy is gaining ground as a biologically sound and clinically effective alternative to RCT in mature teeth. With continued research and standardized clinical guidelines, this approach has the potential to redefine the management of irreversible pulpitis in everyday endodontic practice.

Keywords:
Vital pulp therapy, pulpotomy, irreversible pulpitis, bioceramics, Biodentine, MTA, minimally invasive endodontics, mature permanent teeth.

INTRODUCTION:

The preservation and maintenance of pulpal vitality remains a fundamental objective in endodontics. Traditionally, there has been no clear consensus on the optimal management of vital permanent teeth with cariously exposed pulp. [(1)(2)] Pulpectomy has long been advocated as the treatment of choice to prevent or manage apical periodontitis, with root canal treatment (RCT) shown to yield reliable clinical outcomes in teeth with vital pulps. [(1)(3)] However, evidence indicates that endodontically treated teeth—particularly molars—exhibit significantly lower survival rates compared to vital teeth, with a reported hazard ratio as high as 7:1. [(1)]

This discrepancy may be attributed to the loss of pulp-mediated functions such as proprioception, damping capacity, and pain sensitivity, all of which serve as defensive mechanisms against harmful stimuli. Consequently, the preservation of vital pulp tissue, when feasible, is gaining renewed attention. Vital pulp therapy (VPT), including direct pulp capping, partial pulpotomy, and full pulpotomy, has traditionally been recommended only for teeth with reversible pulpitis, mechanical pulp exposures, or recent traumatic injuries without signs of periapical involvement. [(1)]

However, emerging evidence challenges this paradigm by demonstrating favourable outcomes of VPT even in teeth presenting with carious pulp exposures and clinical signs suggestive of irreversible pulpitis, including those with associated periapical pathology. [(4)] Recent advances in pulp biology and immunology, however, have led to a fundamental shift in this perspective. Histological studies have demonstrated that even in cases of irreversible pulpitis, inflammation is often localized to the coronal portion of the pulp, with the radicular pulp remaining healthy and capable of repair. Furthermore, the discovery of robust regenerative capabilities in pulp tissue, mediated by fibroblasts and mesenchymal stem cells, supports the biological plausibility of healing if the infected coronal tissue is removed. [(5)(6)]

Reflecting these scientific insights, position statements from the American Association of Endodontists (AAE) and the European Society of Endodontology (ESE) now emphasize that a diagnosis of irreversible pulpitis should not automatically mandate full pulpectomy or RCT. Instead, vital pulp therapy (VPT), including full or partial pulpotomy, may be appropriate in many clinical scenarios. These recommendations align with the emerging philosophy of minimally invasive endodontics, where treatment is tailored to preserve as much of the healthy pulp tissue as possible. [(7)(8)]

In addition to being biologically favourable, pulpotomy offers practical advantages: it is less invasive, preserves tooth structure and proprioception, reduces patient discomfort, and is often more cost-effective. [(4)(9)]

This review aims to evaluate the rationale, biological basis, and clinical evidence supporting the use of pulpotomy as a definitive treatment for mature permanent teeth with irreversible pulpitis.

PULPAL DIAGNOSIS AND DEFENSE MECHANISM OF THE PULP:

Accurate diagnosis of pulpal status is essential for guiding treatment decisions, particularly when considering vital pulp therapy (VPT) options such as pulpotomy. The traditional classification provided by the American Association of Endodontists (AAE, 2013) divides pulpal conditions into normal pulp, reversible pulpitis, irreversible pulpitis, and necrosis. [(7)] Within this framework, irreversible pulpitis has historically been considered a terminal diagnosis necessitating root canal treatment (RCT), due to presumed widespread and irreversible tissue damage. [6]

However, histopathological investigations have challenged the assumption that irreversible pulpitis invariably involves the entire pulp. Ricucci et al. demonstrated that in many clinically diagnosed cases of irreversible pulpitis, the inflammation is often confined to the coronal pulp, while the radicular pulp remains histologically normal or only minimally inflamed, supporting the feasibility of pulpotomy in such cases. [6]

Building upon this, Wolters et al. proposed a revised classification system that emphasizes the continuum of pulpal inflammation and healing, rather than a strict dichotomy. This model considers inflammatory burden, extent of tissue involvement, and healing potential, aligning more closely with biological reality, and offering support for conservative VPT options such as partial or full pulpotomy. [10]

The pulp dentine complex itself has an inherent defensive and reparative capacity. When exposed to bacterial byproducts, odontoblasts initiate immune responses and stimulate tertiary dentine formation through reactionary or reparative dentinogenesis. This orchestrated defense mechanism is essential for sealing off the site of injury and preserving pulp vitality if the etiological challenge is adequately removed. Modern VPT techniques are based on this regenerative potential. [11][12]

Currently, clinicians rely on subjective methods such as patient history, clinical exams, sensibility tests, and radiographs to assess pulpal inflammation, with histological analysis being impractical due to its requirement for tooth extraction. There is a pressing need for objective biomarkers that can distinguish between reversible and irreversible pulpitis Research has focused on inflammatory cytokines and MMPs, particularly MMP9, which has shown promise in reflecting pulpal inflammation levels. Clinical studies, found that MMP9/total protein ratios significantly predicted treatment outcomes, highlighting its potential as a real-time, chairside diagnostic tool though such technology has yet to be implemented in endodontics. The incorporation of biomarker-based chairside tools could revolutionize endodontic diagnostics and move the discipline toward true biologically driven care. [6]

INDICATIONS

The indications of pulpotomies include:

- Symptomatic irreversible pulpitis (clinical diagnosis)
- Positive pulp vitality test and controlled bleeding.
- Carious pulp exposure in mature permanent tooth.
- No periapical pathology (radiographically)
- Ability to restore tooth with a durable coronal seal.
- Pulp exposure due to trauma. [12]

CONTRAINDICATIONS

The contraindications of pulpotomies include:

- Tooth that is structurally compromised and that prevents successful restoration and long-term prognosis
- Persistent, profuse, and uncontrollable bleeding or the presence of serous or purulent exudate from the pulp chamber is indicative of underlying radicular pulp inflammation.
- Necrotic pulp tissue.
- Presence of swelling, abscess, or sinus tract.
- Pathological mobility that indicates periodontal involvement or advanced resorption
- Radiological features of internal or external root resorption, intrapulpal mineralisation. [12]

CATEGORIZATION OF PULPOTOMIES

Currently, there is no universally accepted or formal classification of pulpotomy procedures specifically for mature permanent teeth. However, pulpotomy in mature permanent teeth can be categorized on the extent of pulp removal and purpose.

- PARTIAL/CVEK/SHALLOW PULPOTOMY

The concept of partial pulpotomy was originally introduced by Cvek in 1978 as a treatment modality for managing traumatic pulp exposures in immature permanent incisors, wherein calcium hydroxide served as the capping material. [13] Subsequently, this procedure has often been referred to as "Cvek pulpotomy" in numerous studies, signifying its synonymous use with partial pulpotomy. In 1989 Bakland and Boyne proposed the term "shallow pulpotomy" as an alternative designation for partial pulpotomy, further establishing its recognition within dental literature. Cvek defined partial pulpotomy as the removal of approximately 1-2 mm of inflamed pulp tissue underlying the exposure site in traumatic pulp injuries, particularly in immature permanent teeth, with the primary objective of preserving the vitality of remaining healthy pulp tissue. According to Madhumitha et al maintaining pulp vitality through partial pulpotomy can be a definitive treatment alternative to total pulpotomy or root canal therapy, provided that proper case selection, aseptic technique and an adequate coronal seal are ensured. Albaiti et al in his systematic review suggested that partial pulpotomy is a reliable and effective conservative treatment option for managing cariously exposed permanent posterior teeth. [13]

- FULL/CORONAL/TOTAL/CERVICAL PULPOTOMY

Britton first introduced the term "coronal pulpotomy" in 1976, which was later expanded upon by Vinckier et al. with the term "cervical pulpotomy" in 1984 and subsequently by Amini and Parirokh in 2008 with "total pulpotomy". In 2011, Aguilar and Linsuwanont further refined the terminology by introducing "full pulpotomy". Originally indicated for treating exposures of healthy, non-inflamed pulp tissue, full pulpotomy has since been shown to be effective even in cases presenting with irreversible pulpitis in both primary and permanent teeth [1]. Full pulpotomy involves the complete excision of the coronal pulp tissue while preserving the vitality of the radicular pulp, followed by the placement of a biocompatible pulp-protective material to seal the pulp chamber. [14] Ather et al. demonstrated that pulpotomy, when combined with appropriate case selection and biomaterial choice, can be a viable alternative to root canal therapy in managing irreversible pulpitis. Afrashetehfar et al. in his systematic review indicated that there is no significant difference in the postoperative pain between pulpotomy and root canal treatment at 7 days, with both treatments demonstrating high short term clinical success. Louzada et al. found that both partial and full pulpotomy demonstrates similar clinical success rates after one year in managing permanent teeth with irreversible pulpitis.

- MINIATURE PULPOTOMY

Miniature pulpotomy was first introduced by Asgary in 2012 as a refined vital pulp therapy procedure. (15) Miniature Pulpotomy is a conservative vital pulp therapy technique involving the removal of approximately 1mm of superficially inflamed pulp tissue at the exposure site, while maintaining minimal enlargement of the exposure area. This approach is designed to retain the majority of the coronal pulp, facilitating hemostasis and enhancing the adaptation of the pulp capping material to the underlying healthy tissue. The preserved pulp tissue contains undifferentiated mesenchymal stem cells capable of differentiating into odontoblasts like cells, thereby playing a crucial role in pulp healing and regeneration. (16)(17)

- DEEP PULPOTOMY

The partial removal of radicular pulp tissue has been described in literature using terms such as “high amputation”, “radicular pulpotomy” or “deep pulpotomy”, and has been utilized successfully for treating teeth with carious or traumatic pulp exposures. However, this approach is regarded as a comparatively more invasive and technique sensitive procedure than conventional full pulpotomy. The procedure involves the removal of the inflamed coronal pulp to the canal orifices, followed by the precise excision of 2-3 mm of radicular pulp tissue. (18)

- RESTRICTED PARTIAL PULPOTOMY

The restricted partial pulpotomy technique involves the removal of only a minimal thickness of superficial pulp tissue at the exposure site, thereby preserving a greater amount of healthy pulp. In this procedure, pulp excision was limited to the superficial 2-3 mm of the exposed pulp area only, without attempting to de-roof the rest of pulp chamber. This conservative approach can simplify subsequent procedural steps such as achieving haemostasis and placing the capping material with a reduced risk of microleakage, making it less technique sensitive overall. Moreover, by maintaining more pulp integrity, it allows for more accurate assessment of pulp sensibility. (19) However, its limitation lies in the potential inability to eliminate all infected tissue, particularly in cases of extremely deep carious lesions where the thin remaining dentine above the pulp may still harbour bacteria and sustain significant inflammation via dentinal tubules. (20)

- EXTENDED PARTIAL PULPOTOMY

Extended partial pulpotomy involves complete deroofing of pulp chamber regardless of the area of the exposed pulp and excised till the superficial 2–3 mm of the entire chamber. (19) This technique may prove effective in removal of laterally spreading infection. By completely deroofing the pulp chamber, this approach facilitates the elimination of infected dentine and dentinal debris surrounding the exposure site, thereby reducing the bacterial retention, and enhancing wound irrigation. [20] However, despite these advantages, the greater extent of pulp tissue exposure inherent to extended partial pulpotomy renders the procedure more technique sensitive. [19]

CLINICAL STEPS IN PULPOTOMY

Profound anaesthesia should be achieved before the treatment. Isolation of the involved tooth using rubber dam to maintain an aseptic filed and usage of magnification (loupes or microscopes) is recommended for better outcomes. The tooth surface should then be disinfected by rubbing cotton pellets soaked in sodium hypochlorite (1-5.25%). Any residual caries along the cavity walls as well as unsupported enamel should be carefully removed using a sterile round bur and a round end tapered diamond bur mounted on a high-speed handpiece with constant water cooling. Access to the pulp chamber is established by carefully drilling the dentine at the deepest area of the carious lesion. Pulp tissue is excised partially or completely depending upon the type of pulpotomy performed using sterile round carbide bur, in a high-speed handpiece under air-water coolant. Haemostasis is achieved by placing a cotton pellet soaked in 3% sodium hypochlorite over the pulp tissue for 2 minutes. If bleeding persists, the procedure is repeated for a maximum duration of 10 minutes until bleeding is adequately controlled. After achieving haemostasis, the chamber is flushed with 5ml, 3% sodium hypochlorite. Subsequently, hydraulic calcium silicate cement (HCSC) is placed in the pulpal wound to a uniform thickness of 2-3 mm. a layer of resin modified glass ionomer is placed to separate the pulp capping material from the definitive restorative material. This is followed by definitive restoration with composite resin in the same visit. [18][19]

FACTORS AFFECTING PULPOTOMY OUTCOMES

A. TYPES OF VPT AND ITS OUTCOME:

Vital pulp therapy techniques—pulp capping, partial, and full pulpotomy have demonstrated high success rates (~90%) in cariously exposed pulps after one year. [21] For cases presenting symptoms beyond reversible pulpitis, pulp capping is not advised, with full pulpotomy showing favourable results in such scenarios. [22]. Randomized trials comparing partial vs. full pulpotomy have reported no statistically significant difference in outcomes in cases of both reversible and irreversible pulpitis, although full pulpotomy tends to yield slightly higher success rates. Current evidence suggests both techniques may be viable alternatives to root canal therapy, though larger trials are warranted to confirm these findings. [23]

B. RUBBER DAM ISOLATION AND MAGNIFICATION:

The ESE [10] emphasizes the necessity of rubber dam isolation and aseptic technique during management of deep caries and pulp exposure. While rubber dam use is common in university-based trials, it has not been independently validated as a determinant of pulpotomy success. Regarding visual enhancement, ESE [10] also advocates magnification during pulp exposure management, although this guidance is grounded in logical reasoning and indirect evidence. Operator experience and magnification likely influence clinical outcomes, but their individual effects have yet to be isolated and validated through comparative trials.

C. PULPAL HAEMORRHAGE:

Visual inspection of the exposed pulp remains essential; red, vital tissue with no grey discoloration suggests absence of necrosis. Even when abscesses are present, pulpotomy may still be viable. (24) Traditionally, inability to control bleeding within 5–10 minutes has been linked to deeper inflammation, guiding the decision toward pulpectomy. However, studies have shown haemostasis is often achievable in under 6 minutes in most cases, even with irreversible pulpitis. (25) Moreover, recent findings show no significant correlation between bleeding duration and clinical outcome. The AAE supports using haemostasis and pulp visualization as diagnostic tools, but bleeding time alone lacks predictive value for treatment success. (26)

D. PULPAL LAVAGE:

While several irrigants are used to cleanse the pulp wound such as saline, chlorhexidine, and sodium hypochlorite, the latter is most frequently recommended due to its superior antimicrobial effect. (10)(21) Systematic reviews show inconsistent outcomes; one trial reported no significant difference between NaOCl and saline at 24 months, whereas another showed higher success with NaOCl. Still, sodium hypochlorite remains the irrigant of choice, and further randomized trials are needed to establish its definitive role in pulpotomy outcome. (27)

E. WOUND DRESSING MATERIAL:

Recent advancements in hydraulic calcium silicate-based biomaterials have significantly enhanced the success rates of pulpotomy procedures in mature permanent teeth. Traditionally, calcium hydroxide was widely used due to its antimicrobial properties and capacity to induce hard tissue barriers. However, limitations such as high solubility, low mechanical strength, and the formation of tunnel defects have reduced its favourability. These shortcomings led to the adoption of tricalcium silicate-based materials like Mineral Trioxide Aggregate (MTA), which offer improved sealing ability, biocompatibility, and the capacity to release growth factors while inducing dentinal bridge formation. (22) Despite MTA's favourable properties, disadvantages such as tooth discoloration and long setting times prompted the development of newer materials like Biodentine and Calcium-Enriched Mixture (CEM) cement. Biodentine offers faster setting, greater calcium ion release, and less discoloration compared to MTA. CEM, introduced in 2006, shares similar clinical efficacy with better physical properties and shorter setting time. A meta-analysis by Ather et al. showed that Biodentine significantly outperformed MTA, CEM, and calcium hydroxide in pulpotomy success rates, likely due to its superior ion release and bioactivity. (13) MTA was found to be more successful than calcium hydroxide, while CEM and calcium hydroxide had comparable outcomes. These findings are consistent with a systematic review by Sabeti et al., which reported a 93% success rate for bioceramic materials in vital pulp therapy. (28) Other contemporary materials such as TotalFill BC and EndoSequence BC Root Repair Material (RRM) have also shown promising results. A retrospective study by Mutluay and Akgun reported a 90.7% overall success rate in full pulpotomy, with Biodentine achieving 100% success and EndoSequence 82%. Similarly, TheraCal LC, a light-cured resin-modified calcium silicate, and iRoot BP Plus, a premixed injectable bioceramic, have demonstrated clinical success rates close to 90%, along with improved handling and patient comfort. Although ferric sulfate remains useful for hemostasis, it lacks regenerative potential. Overall, systematic reviews and randomized controlled trials report pulpotomy success rates between 86% and 97%, supporting the use of modern bioceramic materials as reliable, tissue-conserving alternatives to root canal therapy. [28]

E. PULPAL BIOMARKERS:

Current diagnostic approaches for assessing pulpal inflammation rely heavily on subjective clinical tools such as patient history, sensibility testing, radiographs, and visual inspection, all of which lack definitive predictive accuracy. Histological evaluation, though considered a reference standard, is impractical in vivo as it necessitates tooth extraction. [29]

Matrix metalloproteinases (MMPs), especially MMP9, have emerged as promising diagnostic indicators. Studies have demonstrated elevated levels of MMP9 in symptomatic pulpitis cases, with quantifiable differences observed among various clinical presentations. [29]A randomized trial by Ballal et al. [21] showed that the MMP9/total protein ratio (MMP9/TP) was significantly associated with the severity of pulpal inflammation and could predict treatment outcomes following pulp capping.

A rapid, chairside diagnostic tool holds promise for transforming VPT by enabling real-time pulpal health assessment using small samples like pulpal blood or dentinal fluid. Though still under development, such innovation could greatly improve diagnostic precision and support minimally invasive endodontic treatment.

F. CORONAL SEAL, POSTOPERATIVE PAIN AND LONG TERM MONITERING:

The restorative material significantly affects treatment longevity. Studies associate glass ionomer restorations with increased failure, emphasizing the need for durable coronal sealing. While one systematic review found no difference between composite and amalgam, restoration quality remains a key determinant of clinical success. [30]

A secure coronal seal is fundamental to the success of vital pulp therapy (VPT) and endodontic treatment, ensuring both structural integrity and biological function. The same restorative standards applied to root canal–treated teeth should be extended to VPT-treated cases. Posterior teeth with missing proximal walls require cuspal coverage—either via direct or indirect restorations—to enhance longevity and stability.

Postoperative pain, a frequent concern in VPT, is typically milder than after single-visit root canal therapy (RCT). Meta-analyses indicate pulpotomy results in lower rates of moderate-to-severe pain within the first 72 hours and shows a higher incidence of no pain. Follow-up is key to evaluating treatment success. VPT failures may be early (within 3 months) due to persistent symptoms or late (after 6 months) owing to new pathologies or restorative failure. The ESE (2019) recommends clinical review at 6 months, followed by clinical and radiographic evaluations at 12 months, and annually up to 4 years if indicated. [10]

CONCLUSION:

The evolving understanding of pulp biology and inflammation has catalyzed a conceptual shift in the management of irreversible pulpitis in mature permanent teeth. Clinical evidence is increasingly supporting pulpotomy, particularly when bioactive materials like mineral trioxide aggregate (MTA) or

Biodentine are employed as a biologically reliable and clinically viable alternative to traditional root canal therapy. Once restricted to primary or immature teeth, pulpotomy is increasingly being recognized for its ability to preserve pulpal vitality, reduce procedural complexity, and deliver comparable success rates. As clinical trials continue to demonstrate promising outcomes, it is imperative that the endodontic community embraces this conservative approach, promotes further high-quality research, and develops clear, evidence-based guidelines to optimize its application in daily practice.

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ORIGINAL RESEARCH

Continued Etching of Wet Dentinal Tubules by Single Bottle And Two Bottle Self Etch Adhesive-A Comparative In Vitro Study

Dr. Veena S Pai[1], Dr. Roopa R Nadig[2], G Usha[3]

1-Professor and HOD,2 & 3- Private Practitioners

Address for correspondence: Dr. Veena S Pai, Professor and Head, Departments of Conservative Dentistry and Endodontics, The Oxford Dental College, Bangalore, Contact no: 9886861743, Email id- drveenapai@gmail.com

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Abstract

Background and objectives: Monomers used in self etch adhesives (SEA's) are made sufficiently acidic in order to ensure effective penetration through smear layer. This study was done to determine whether acidic monomer in the fluid filled dentinal tubules would retain their acidity and continue to etch or demineralize the surrounding dentin.

Materials and Methods: Twenty extracted third molars with Occlusal 1/3rd of crowns sliced were used. Prepared dentin surfaces divided into following groups and treated accordingly - Group1 - G Bond (one step SEA) and Group2 – Unifil Bond (two step SEA), stored in saline separately for 24hrs and four slabs from each tooth obtained. Two slabs analyzed at 24hrs for degree of conversion (DOC) and two slabs stored for 4 weeks and analyzed for dentin integrity using Micro-Raman spectroscope. **Results and Conclusion:** Spectroscopic analyses indicated DOC of monomer at surface was consistently greater than in deeper hybrid layers in all specimens. After 4 weeks, significant degree of continued demineralization and collagen degradation was noted in both groups though not statistically significant when 4 weeks specimen groups were compared with each other. Both single and two step SEA showed statistically significant degree of continued demineralization and collagen degradation after 4 weeks. Continued demineralization and degradation could be attributed to unpolymerized acidic monomer. The relationship between the variables like pH, technique of application, DOC, storage of specimen and adhesive, composition of 3 adhesives and its' effect on the degradation of the D/A interface should be further evaluated through long term in-vitro and in-vivo studies.

Key words: Self etch adhesive; Unifil bond; G Bond; degradation; Micro Raman Spectroscopy; Continued etching.

INTRODUCTION

Adhesive system can be categorized on how they treat smear layer. The traditional total-etch system removes smear layer and smear plugs and demineralise the subsurface dentin which is replaced by adhesive monomer which was not always possible owing to the sensitivity of technique. Slightest variation in the steps involved – etching, rinsing, drying etc resulted in a hybrid layer that contained voids, usually seen at the bottom of hybrid layer. [1]

In order to simplify and overcome the sensitivity of the wet bonding technique, self-etch systems were introduced. Although the bond strengths are not high as two step systems as reported in many in-vitro studies, single step adhesives have an advantage of simple bonding procedure with reduced technique sensitivity but greatest concerns of self-etch adhesive systems refers to whether they are acidic enough to produce adequate demineralization. The pH is a key factor to determine the penetration potential throughout dentin and depth of demineralization. [2]

It has been reported that although these self-etch adhesives are highly acidic, the DOC of these acidic monomer at the surface and within the tubules is high enough that the acidic reaction would be self limiting. However there are certain controversial reports to show that the acidity of the unpolymerized monomer may be retained and continue to affect or demineralise the surrounding dentin resulting in unprotected collagen fibrils susceptible for hydrolytic degradation[3]. Therefore the self-etch concept although theoretically appears perfect, it needs to be thoroughly analysed for their acidity and its' effect on wet fluid filled dentinal tubules. The study was undertaken with the null hypothesis that there was no significant difference between single step and two step self etch adhesive (SEA) with respect to their 1) degree of conversion(DOC) and 2) maintaining the integrity of dentine with the objective to determine whether the unpolymerized acidic monomer in the fluid filled dentinal tubules would retain their acidity and continue to etch or demineralize the surrounding dentin.

MATERIALS AND METHOD:

Methodology:

Dentin Adhesive Specimen Preparation:

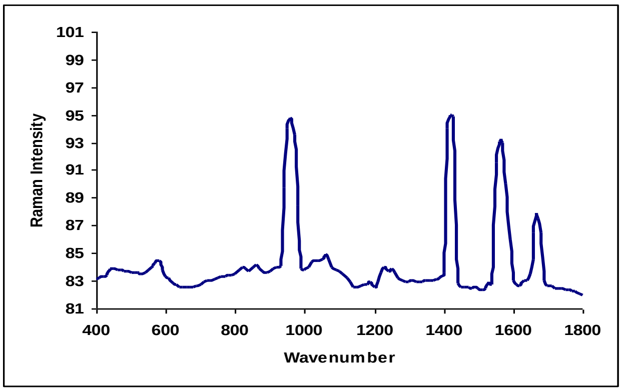
Occlusal one third of Intact non-carious molars were removed by diamond disk and Smear layer created. The prepared dentin surfaces were divided into following groups and sectioned longitudinally into four rectangular slabs (8x1.5x1.5mm) having Dentin-adhesive inter face.

Group1. Single bottle SEA- G Bond (10 Molars)

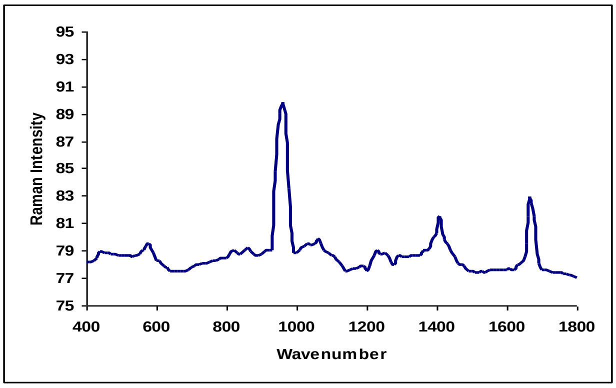
Group 2: Two bottle SEA- Unifil Bond (10 Molars)

Two slabs from one tooth were analysed after 24 hrs under MRS for the DOC at the D/A surface, 10µm and 20µm into dentin. The chemical structure of bonded Dentin after 24hrs was analysed to compare with the four weeks specimen to measure if any demineralization has occurred (Graph 1). Two slabs from same tooth were analysed after 4 weeks under MRS to determine whether the residual monomer, if any, would alter the chemical structure of dentin.

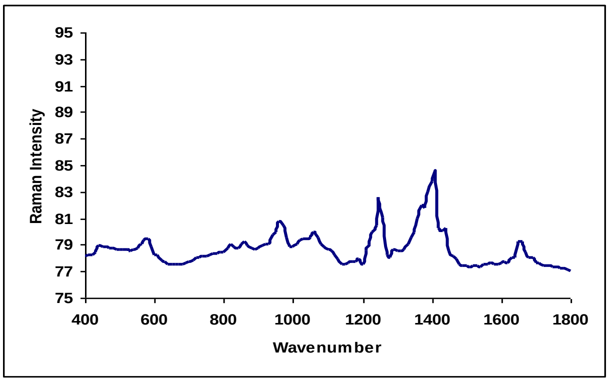
Spectral Readings Used As Standards-Graph 1



Graph 1a - MRS spectra obtained for Normal dentin - peaks at 960cm-1(phosphate) and 1666cm-1 (amide I) used as internal standards.



Graph 1b- MRS spectra obtained from uncured G Bond adhesive system. Intensity of peaks- 1657 cm^{-1} and 1422 cm^{-1} used as internal standards.



Graph 1c- MRS spectra obtained from uncured Unifil Bonding agent. Intensity of peaks- 1410 cm^{-1} and 1245 cm^{-1} used as internal standards.

Quantifying the Spectral Readings:

Spectral data from the data interfaces were compared with reference spectra of pure adhesive and normal dentin.

Evaluation of Degree of conversion

Group 1 (G Bond), the DOC was measured in MRS by measuring intensity ratio (R) of the vibration bands of aliphatic C=C stretching mode at 1567 cm^{-1} and aromatic C=C stretching mode at 1422 cm^{-1} used as internal standard. Readings were calculated at D/A surface, 10µm, and 20µm into dentin (Graph 1b,2a)

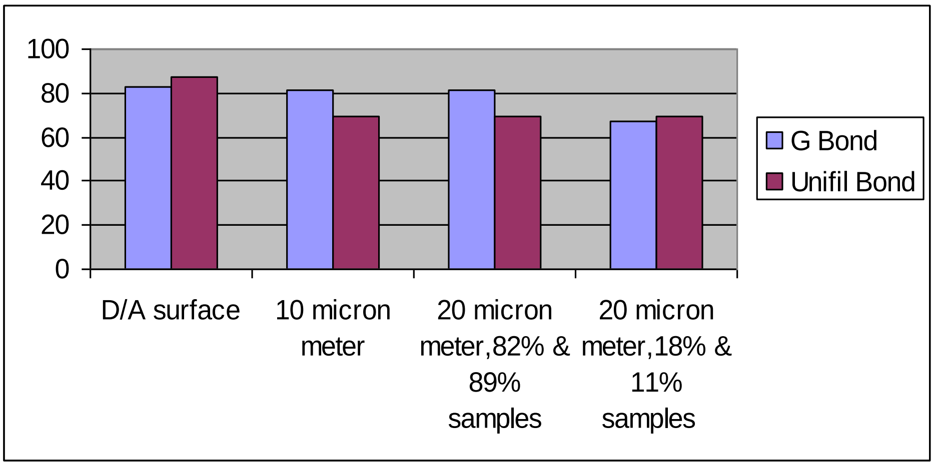
Group 2 (Unifil Bond), the degree of conversion (DC) was measured in MRS by intensity ratio (R) of the vibration bands of aliphatic C=C stretching mode at 1410 cm^{-1} and the aromatic C=C stretching mode at 1245 cm^{-1} used as internal standard. Readings were calculated at D/A surface, 10µm, and 20µm into dentin

Evaluation of demineralization and degradation of dentin

The intensity of peak 960 cm^{-1} representative of mineral content of normal dentin by PO_4 vibration and 1666cm^{-1} representative of organic content of dentin by amide I were taken as standards (Graph 1a) to compare readings of same peaks after Bonding and after four weeks storage to analyse the changes in the organic and inorganic component in the dentin samples (Graph 2d, 3d).

RESULTS AND DISCUSSION

The DOC of adhesives is an important clinical parameter since low mechanical properties are related with low percentage of monomer to polymer conversion. On comparing the DOC between two groups no significant difference was found between the groups (Graph 4). This result is in conformity with most of the studies comparing the degree of conversion of adhesives using one-step [3] and two-step adhesive.



Graph 4- Bar graph showing Degree of Conversion in Group 1 and Group 2

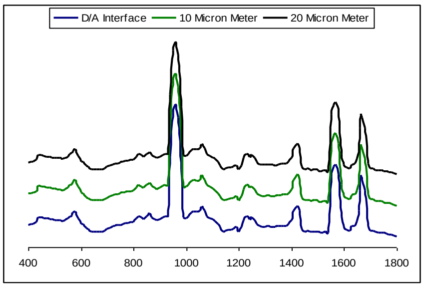
The results also indicates that in the deeper layer of hybrid layer there is increased probability of incomplete conversion irrespective of the number of steps involved. As discussed by Carvalho in his review on SEAs, the highly hydrated dentin substrate as it nears the pulpal chamber might interfere with the polymerization as well as penetration of the monomer into the tubules. [4] DOC has been shown to vary with the technique of application, curing method, curing unit used and also the composition of the adhesive. Simplified adhesives with 50% of solvents in their composition have shown to lower the degree of conversion.

The second part of study evaluated the integrity of adhesive treated dentin substrate after 4 weeks. Dentin substrate of 18% of G-Bond group (Graph 2d) and 11% of Unifil group specimens (Graph 2d), which were intact initially (24hrs specimen analysis) showed mineral loss after 4 weeks. This was indicated by the decreased intensity of the phosphate (960 $cm^{-1)}$ and amide peak (1666$cm^{-1)}$ confirming demineralization and degradation at 20µm.

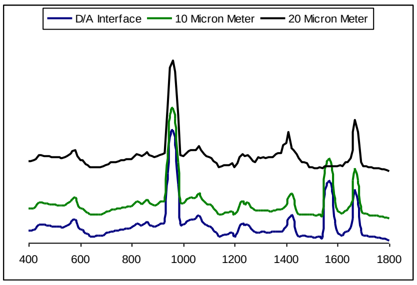
The Z test done for proportionality within each group, showed statistically significant degradation in both the groups indicating continued demineralization over time. However, there was no statistically significant difference ($p > 0.05$) between the groups tested in this study thus accepting the null hypothesis, which is in agreement with the study by Wang et al. [3]

Results after MRS analysis

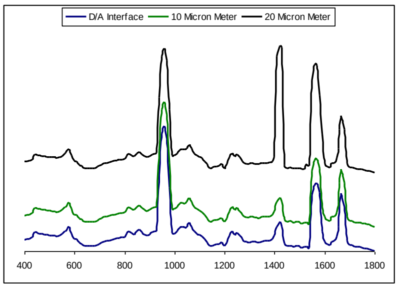
Raman spectra of G bond group (graph 2)



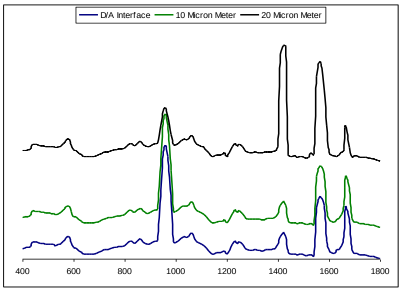
Graph 2a – Spectral readings of cured samples at three different depths after 24hrs.



Graph 2b - Specimens showing no penetration at 20µm. Note the intensity of peak 1567cm^{-1} and 1422cm^{-1}

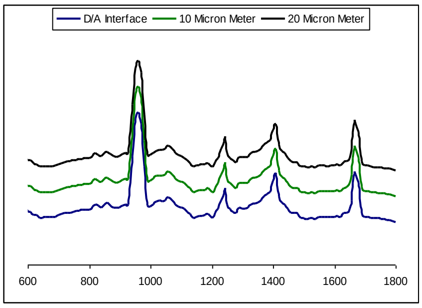


Graph 2c - showing peak intensities similar to the uncured resin at 20µm indicating sub-optimal polymerization.

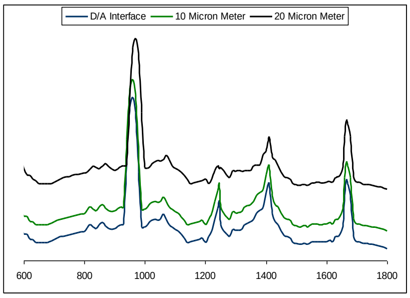


Graph 2d – specimens which showed suboptimal polymerization, show reduced intensity of peak 960cm^{-1}, indicating demineralization at 20µm.

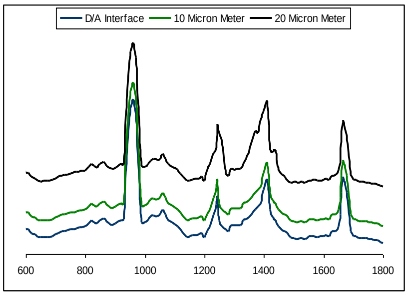
Raman spectra of Unifil bond group (graph 3)



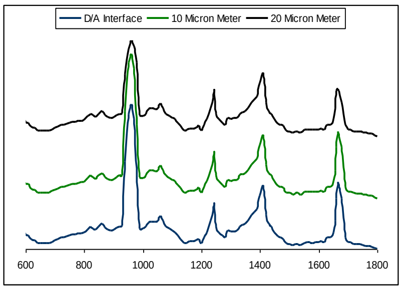
Graph 3a - Spectral readings of cured samples at three different depths after 24hrs.



Graph 3b - group 2 specimens showing no penetration. Note the intensity of peak 1245cm^{-1} and 1410cm^{-1} at 20µm.



Graph 3c - Unifil bond group showing peak intensities similar to the uncured resin indicating suboptimal polymerization at 20µm.



Graph 3d – specimens which showed suboptimal polymerization, showing demineralization indicated by the reduced intensity of peak 960cm-1 at 20µm.

Few studies suggest that in adhesives with pH < 1, the smear layer is dissolved and the tubules are opened up resulting in dilution and phase separation of adhesive solution decreasing the tendency of hydrophilic and hydrophobic monomer to polymerize as copolymers. The unpolymerized monomer remains acidic and continues to etch the underlying dentin after hybrid layer formation. Kitasako et al concluded that the mild acidic SE monomers are neutralized as they bind and dissolve calcium and phosphate ions from the tooth surface making the acidic action self-limiting thus causing no damage to the substrate which is in contrast to our results. The SEA used in the present study were of pH 2.0 (G Bond) and pH 2.2 (Unifil Bond), which although considered mild was less than that used by Kitasako et al. [5] Therefore the effect of different pH and its relation to the demineralization of dentin and polymerization of adhesives needs to be further evaluated.

While Nanoleakage has been reported with both total-etch and self-etch adhesives, the latter seem to have shown greater degree of nanoleakage owing to the higher content and hydrophilicity of the solvents. This makes the hybrid layer more porous and more water is absorbed into the polymer overtime causing swelling of resin by hydrogen bonding of water on hydrophilic domains of polymer chains. The residual unreacted monomer is eluted from hybrid layer creating new channels of water penetration, through which the water diffuses even more in an auto-accelerative manner. The elution of residual monomer and low weight polymers also cause an increase in porosity with in hybrid layer and lower the cohesive strength of adhesive. The resulting bond strength value is also lowered thus weakening the D/A bond. Moreover the D/A bond is rendered unstable over a period of time due to demineralization of dentin.

Tay et al showed that it is difficult to evaporate water from all-in-one adhesives, and even if evaporation is successful, water will rapidly diffuse back from the bonded dentin into the adhesive resin. This water sorption plasticize polymers and lowers their mechanical properties. Although hydrophobic dimethacrylate are added to all-in-one adhesives to produce stronger cross-linked polymer networks, the hydrophilic monomers tend to cluster together before polymerization to create hydrophilic domains and microscopic water-filled channels called “water trees.” These ‘water trees’ permit movement of water from the underlying dentin resulting in degradation of bond. [6]

Biodegradation of the collagen matrix and/or hydrophilic resin components within the hybrid layer may be related to: (1) Incomplete infiltration of resin into the dentine (2) Heterogeneous distribution of resin monomers through the interdiffusion zone (3) Suboptimal polymerization in the presence of water 4) Alterations of the organic matrix during preparatory procedures (5) Hydrolysis of polymeric components or unprotected collagen.

A study concluded direct exposure to water affected bonds produced by two step total-etch adhesives. [7] In the present study though the specimens were directly exposed to water, the storage period was only 4 weeks. In the oral cavity as DBA’s are generally covered by restorative resins or other restorations, direct exposure can hardly be expected unless in cases of marginal microleakage. Hence further long term in-vivo and in-vitro studies addressing these aspects should be conducted.

Several reasons have been advocated to account for the suboptimal bonding performance of these simplified adhesives: (1) the more aggressive etching process, which may destabilize the collagen matrix (2) a weaker cohesive strength of the adhesive resins (3) a low degree of conversion of the resin monomer in these simplified adhesives (4) the formation of ‘‘water-trees’’.

CONCLUSION

The following conclusions could be drawn from the present study

1. DOC of the monomer to polymer at the surface was significantly higher than that found deeper within the tubules in both single and two step adhesives.
2. There was no significant difference in the DOC between the two groups tested (Graph 4).
3. Both single step and two-step SEA showed Statistically significant degree of continued demineralization and collagen degradation after 4 weeks of water storage.
4. There was no statistically significant difference in the demineralization and collagen degradation after 4 weeks of water storage between the groups tested.
5. Continued demineralization and degradation could be attributed to the unpolymerized acidic monomer within the hybrid layer.

6. The relationship between the variables like pH, technique of application, DOC, storage of specimen & adhesive, composition of adhesives and its’ effect on the degradation of the D/A interface should be further evaluated through long term in-vitro and in-vivo studies.

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CASE REPORT

Endodontic Management of Mandibular Left Canine Having Two Roots With Two Canals: A Case Report

Dr. Sunny Agarwal[1], Dr. Ramya Raghu[2], Dr. Raghu Srinivasan[3], Dr. Shyamsiddha Mal[4]

1- Private Practitioner,2,3 –Former Professor and HOD, 4- Private Practitioner

Address for correspondence: SUNNY AGARWAL
DENTFIX Clinic, Shop no. 12, Nimbus Centre, Sab Tv lane, Opp. Laxmi Industrial Estate, Andheri West, Mumbai – 400053.
Email Id: drsunnyagarwwal92@gmail.com

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ABSTRACT

Endodontic treatment may sometimes fail because morphological features of the tooth adversely affect the treatment procedures. Mandibular canine presents a complex internal anatomy. Generally, mandibular canines presents with a single root and a single canal in the majority of the cases. Rarely, two roots with two separate canals can occur. The existence of mandibular canines with more than one root canal is a fact that clinicians need to keep in mind to avoid failure during endodontic treatment. Clinician’s knowledge of the different anatomy of every tooth, access opening, and biomechanical preparation followed by three-dimensional obturation of the root canal is important for the success of root canal therapy. This paper presents a case report of a mandibular left canine having two roots with two separate canals.

Keywords- Mandibular canine, two roots, two canals, endodontic management, anatomy.

INTRODUCTION

The endodontic treatment aims to remove the infected nerve tissue and microorganisms from the root canal and create a three-dimensional seal that further prevents reinfection in that tooth. Failure of the root canal treatment may lead to postoperative pain and infection. [1,2] Morphological features of the tooth may also affect the outcome of the endodontic treatment. [2] In dental treatment, every tooth is different and has different anatomy. One of the reasons for the failure of the Root Canal Treatment is missed canals which may lead to incomplete removal of pulpal or infected tissue from the root canal. [3,4] So clinician's proper knowledge and experience are required to deal with the aberrant morphology of the tooth. [3,4,5] Normally, the mandibular canine has one root with a single canal [6,7,8]. Many clinicians have reported permanent mandibular canine associated with various anatomical variations. The occurrence of mandibular canines with one root and two canals is approximately 15% and two roots with two separate canals is rare but ranges from 1 to 5% as reported by Pineda and Kuttler [6], Green [9], and Vertucci [7]. [10,11,12,13] Unpredictable findings in the root canal anatomy of mandibular canines may have a great impact on the success of the root canal treatment. Various techniques are used to clinically investigate the root canal system which includes direct evaluation during root canal therapy with magnifying tools such as loupes and microscope, conventional and digital radiography at different angulations, and CBCT. Conventional periapical radiographs are occasionally unreliable for determining the location, nature, and shape of structures within the root and the distance between the root(s) and surrounding anatomical structures and associated peri-radicular lesions. Cone-beam computed tomography (CBCT) is a more precise diagnostic tool to evaluate the morphology of the root canal, which establishes the length, number, curvatures, and bifurcations of the roots in both the sagittal and axial planes. [3,4,13,14] As CBCT is more precise, it is considered superior to conventional techniques. This paper reports the successful management of a mandibular canine having two roots and two canals.

CASE REPORT

A 53-year-old woman presented with pain in the lower left front tooth region for 2weeks. The patient's medical history was non-contributory. Clinical examination revealed a Porcelain fused to metal bridge from 33 to 36. The diagnostic radiograph showed vital 33 and RCT treated 34. On examination of radiographs taken at multiple angulations, it was observed that the canine presented with 2 roots and 2 canals.

Fig. 1 Pre-op X-ray showing mandibular left canine with two roots and two canals.

Based on the history and clinical examination, the patient was advised to get the replacement of the bridge and RCT with 33. As the patient was going abroad in 4 days and due to time constrain patient only wanted to get the Root Canal Treatment done. Rubber dam isolation was not possible in this case as patient already had bridge in her mouth. We decided to do the Root Canal Treatment through the crown and the replacement of the bridge would be done when patient visits India next time. Informed consent was taken from the patient.

Endodontic treatment was initiated after administrating local anaesthesia. Local anesthesia was induced using 2% lidocaine and epinephrine (1:80,000) was administered. Endodontic access was performed with a tungsten carbide crown cutting bur (prima dental) and EndoZ tapered safe end bur (Dentsply Maillefer, Switzerland) for locating both the canals. DG 16 probe was also used to locate buccal and lingual canal. Root canals were negotiated using size 8, 10 and 15 K files (Mani, Japan). Working length was determined with an iPex electronic Apex Locator (NSK, Tochigi, Japan) and reconfirmed radiographically.

Image. 1 Access opening done with 33 through the crown. Both buccal and lingual canal found.

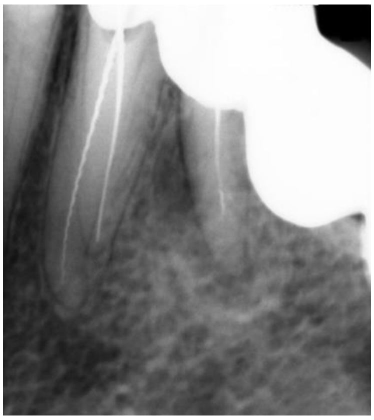

Fig. 2 Working Length X-ray showing k files placed till the full length of both buccal and

Biomechanical preparation was done up to 30.04% file size (Neo Endo flex) using EDTA lubrication (RC–Prep, Dentalcompare, USA) under constant irrigation of 3% NaOCl and saline at each change of file. Master cone radiograph was taken and Obturation was performed using 30.04% GP cones using AH Plus Sealer (Dentsply Maillefer, Switzerland).

Image. 2 Gutta percha sealed at the orifice level of both the canals.

Fig. 4 Obturation X-ray showing Gutta Percha cones coated with AH Plus sealer placed in both the canals sealed at the orifice.

DISCUSSION

Detecting anatomic variation early can favour the success of the endodontic treatment. For this, it is very important for the dentist to carefully inspect the diagnostic radiograph as it is helpful to be aware of the importance of detecting a sudden loss in the continuity of the root canal lumen or radiolucent groove in the lateral part of the root, which gives us the hint of the presence of more than one canal. Clark's technique or angled radiograph at 20-25° can also help us in detecting extra canals. Advanced techniques such as CBCT can also be used to detect internal variations but have some limitations such as high radiation dose to the patient, high level of scatter and noise and possible artefact generation.[15]

Treating a mandibular canine with normal anatomy does not cause any procedural errors during instrumentation but treating a mandibular canine with two roots and two canals poses difficulty during instrumentation as the long axis of the canal meets the crown surface at the incisal edge or on the labial surface. So precaution needs to be taken especially on the buccal surface to avoid any mishap or procedural error such as blockage, ledge formation, instrument separation and lateral perforation if instrumented with large size files. Therefore, meticulous care should be taken during biomechanical preparation with copious irrigation using sodium hypochlorite and EDTA. Proper diagnosis and identifying all the root canals in the tooth play an important role in the successful outcome of the root canal treatment.[16]

In the present case, two roots with two canals were detected using an angled radiograph. DG 16 endodontic explorer was also used to detect extra-canal. Two separate canals were present from the orifice to the apex. Vertucci observed only 6 teeth with Type IV canal configuration (two separate and distinct canals from the pulp chamber to the apex).[1,7] As access opening was done through the crown, cotton was placed around the file while determining the working length using the Apex Locator to get the accurate length of both canals. A recent meta-analysis study by Martins et al showed that there was high occurrence of mandibular canine second root and root canals in female individuals. This analysis was conducted on different age groups which showed high proportions of 2 root configuration in older patients. It can be due to aging calcification process, which typically presents a calcification pattern in the mesio-distal direction in oval root canals- a characteristic feature shared by mandibular canine because of wide cross-section buccolingually. This calcification pattern may lead to deposition of dentin in the center of the root canal which splits into two. Same study also showed the patient demographics and anatomic features of mandibular canine including india sample size was 300 teeth in which 16 teeth that is 5.3% of patient had two roots and 15 teeth that is 5% had two independent canals with multiple exits.[17]

Few important points to be remembered while treating mandibular canines. Failure to control infection or untreated or missed canal may have an adverse impact on treatment outcome. Clinicians should be aware of anatomical variations in the teeth they are managing and should never assume that canal systems are simple. The majority of mandibular canines have one root and root canal, but 15% may have two canals, and a smaller number may have two distinct roots.

CONCLUSION

Although the occurrence of mandibular canines with two roots and two canals is very uncommon, these morphological variations present with technical difficulties during root canal treatment. The sudden narrowing of the root canal lumen and a radiolucent grove in the lateral part of the root is indicative of the presence of more than one canal. To manage such cases clinicians should be aware of the anatomical variations that can occur in the teeth which they are treating. These cases can be better performed using newer techniques and equipment including ultrasonic tips for conservative access, an electronic apex locator to determine the accurate working length and a dental operating microscope for improved visibility and accessibility and under rubber dam isolation.

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