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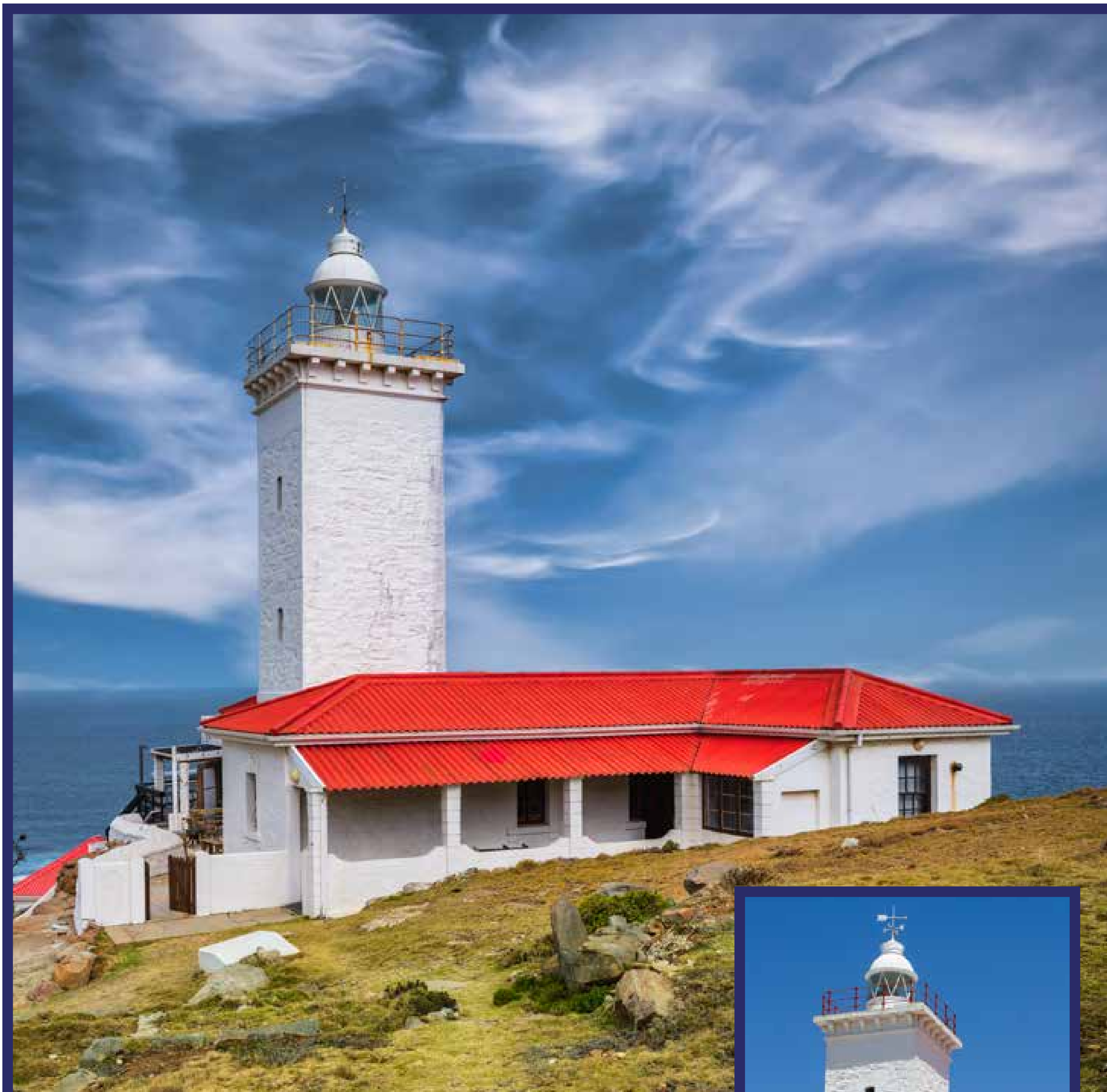

Cape St. Blaize Lighthouse

The Cape St. Blaize Lighthouse, built in 1864, stands atop the cliffs of Mossel Bay, guiding ships along South Africa's southern coast. Its white tower, still operational today, offers panoramic views of the Indian Ocean. The lighthouse remains a historic maritime beacon and popular tourist stop, with a scenic trail nearby that leads to the St. Blaize Cave.

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Our Front Cover for this Issue...

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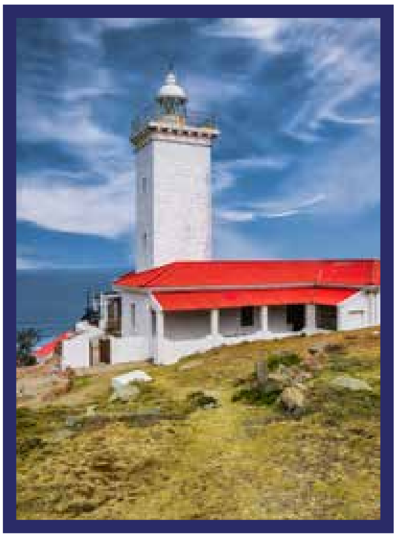

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The Ghost Curriculum: What are we NOT teaching our students?

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Prof NH Wood, Managing Editor, SADJ – BChD, DipOdont(MFP), MDent(OMP), FCD(SA), PhD

Unseen lessons, unspoken challenges

In every curriculum document, carefully scaffolded modules outline the knowledge and skills deemed essential for competent dental practice. Yet, within the margins of these structured learning outcomes, and skirting the oft-mentioned hidden curriculum, lies a parallel curriculum: unwritten, unspoken, and often unexamined. This "Ghost Curriculum" comprises critical topics and competencies that are either superficially addressed or entirely absent, despite their profound impact on the personal and professional journeys of our dental graduates.

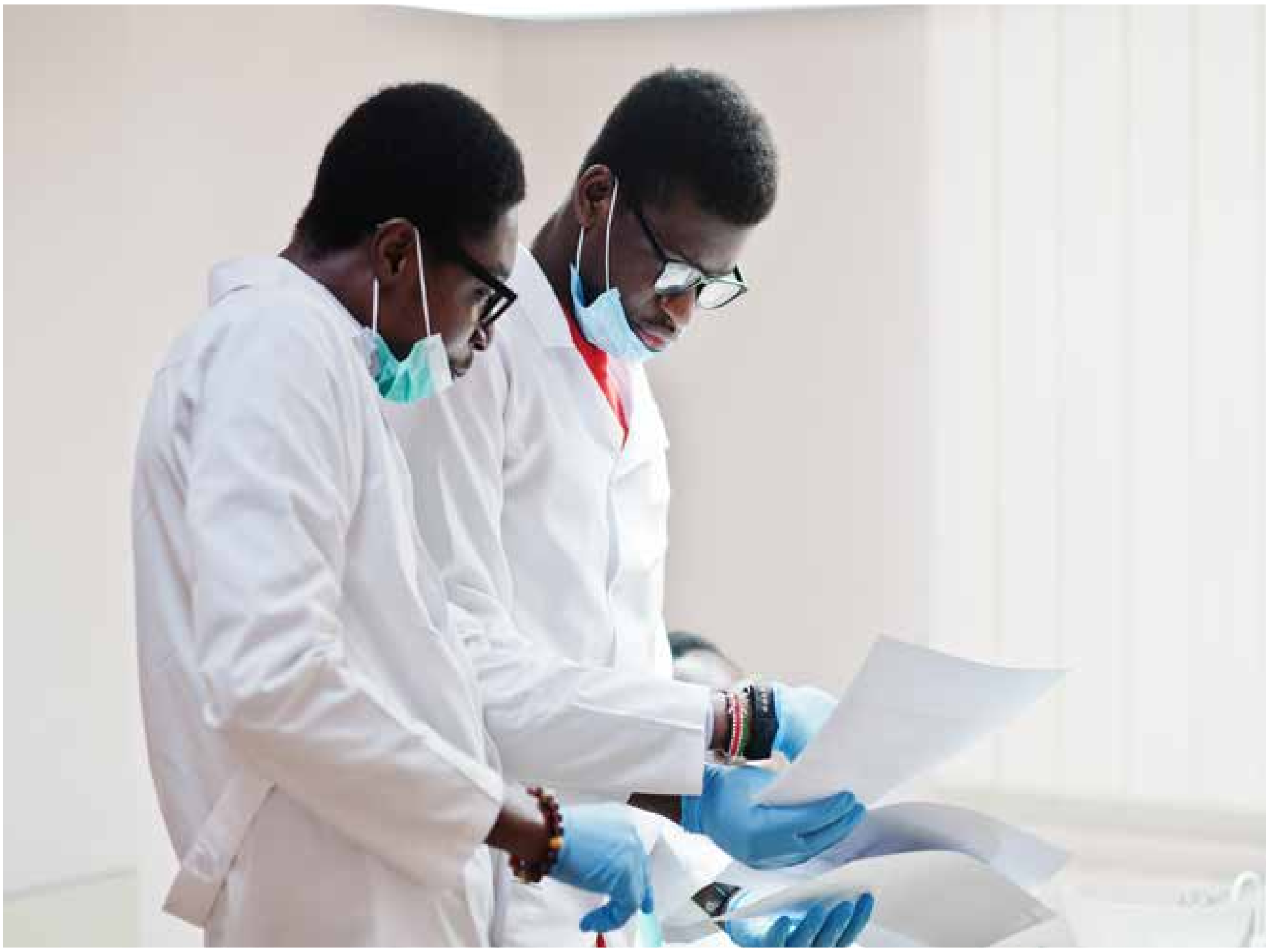
From burnout and ethical ambiguity to environmental sustainability and post-graduate life planning, today's dental students are graduating into a profession fraught with complexity and contradiction. The essential traditional curriculum, clinical, scientific, and technical, is no longer sufficient on its own to prepare graduates for the nuanced realities of 21st-century dental practice.

In this editorial I aim to illuminate the blind spots, not to undermine the existing curriculum, but to invite introspection and dialogue. What are the hidden costs of omitting difficult conversations? Who is affected when equity, wellness, and sustainability are afterthoughts rather than embedded principles? Can we afford to teach the hand without nurturing the heart and the mind? In exploring the ghost curriculum, we are not chasing shadows. We are giving shape and voice to that which haunts the edges of our educational frameworks, urgent truths we ignore at our peril.

Mental health and resilience: the silent crisis

Behind the polished smiles and clinical precision of dental professionals lies a largely unspoken epidemic: mental health challenges that begin during undergraduate training and often persist throughout one's career. Dental education is notoriously high-pressured, marked by demanding academic loads, intense clinical requirements, and the persistent pursuit of perfection. These pressures are often normalized, internalized, and unaddressed.

Studies from South Africa and abroad have consistently reported high levels of stress, anxiety, and burnout among dental students. Yet, formal strategies to support mental



wellness, such as resilience training, emotional intelligence development, or coping mechanisms for clinical failure, remain peripheral, if present at all. Informal spaces, like peer support or mentorship, are inconsistently available and rarely framed within structured support systems.

The result? Many students graduate with a well-developed handpiece technique but a poorly equipped psychological toolkit. They enter private practice or community service with limited training on how to manage the emotional toll of patient dissatisfaction, treatment complications, financial pressure, or professional isolation. What's more, self-care is often implicitly framed as indulgent or secondary, rather than essential. This ghost lesson, that mental wellbeing is one's personal burden to quietly bear, reinforces a culture of silence and stoicism that can erode professional longevity and personal fulfilment.

Resilience, when taught and supported explicitly, is not a luxury, it is a foundation. The ability to navigate failure, regulate emotion, and seek help when needed is as vital as any technical skill. In a profession where perfection is idealized and mistakes carry real-world consequences, students must be prepared not just to endure stress, but to grow through it. recognising mental health as a legitimate domain of professional competence is the first step toward rewriting this part of the ghost curriculum. The next step is to embed it, not as an add-on wellness week, but as a longitudinal thread interwoven with clinical and academic experiences.

The ethics of the business: teaching financial literacy and integrity

For many new graduates, the transition from dental school to clinical practice is accompanied by a rude awakening: dentistry is not only a healthcare profession, it is also a business. Yet few students receive adequate preparation for the ethical, financial, and operational decisions they will face daily.

Practice ownership, employment negotiations, treatment planning under financial constraints, and balancing quality with affordability all require nuanced decision-making that extends well beyond the biomedical model. Without foundational knowledge in financial literacy, many young dentists make early career decisions that lead to debt mismanagement, professional dissatisfaction, or ethical compromise.

Even more concerning is the subtle but powerful influence of industry. Sponsored education, product placement, and incentives can shape prescribing patterns, material choices, and treatment recommendations, often without conscious reflection. This intersection between commerce and care is rarely explored in undergraduate curricula, leaving students vulnerable to manipulation or conflict of interest.

Moreover, critical discussions on ethical gray zones, like overtreatment, cosmetic upselling, or the pressures of meeting financial targets, are often absent. The silence around these issues suggests they are either taboo or not important enough to warrant curricular time. Yet these are precisely the dilemmas that cause moral injury and erode public trust when poorly navigated.

Embedding business ethics and financial literacy into the curriculum is not about turning students into accountants or cynics. It's about giving them the tools to practice with clarity, confidence, and conscience. It is about cultivating a new generation of practitioners who can maintain ethical integrity in the face of commercial realities, and who are equipped to lead sustainable, principled practices. In doing so, we reframe the business of dentistry not as a necessary evil, but as an opportunity for ethical leadership and responsible innovation.

Social justice, equity, and the call beyond the chair

Dentistry, by its very nature, is both intimate and impactful, it affects how people eat, speak, smile, and interact with the world. Yet the stark disparities in access to dental care remain a global concern, and South Africa is no exception. Despite our constitutional commitment to equality, oral health inequity continues to persist across rural-urban divides, socioeconomic classes, and vulnerable populations such as the elderly, institutionalized, or disabled.

Still, undergraduate dental education often fails to explicitly address issues of social justice, advocacy, and the structural determinants of health. Outreach programmes are typically short-term and charity-driven, well-meaning but insufficient. They rarely cultivate the skills, attitudes, and critical consciousness required to become long-term advocates for public oral health.

What if students were challenged to reflect more deeply on their positionality as future health professionals? What if curricula encouraged them to interrogate the systemic forces that produce inequity: poverty, racism, access to fluoridated water, food insecurity, or the politics of resource allocation? What if advocacy was framed not as optional, but as intrinsic to being a healthcare professional?

Equity cannot be achieved through clinical competence alone. It demands moral courage, public health literacy, and an expanded sense of duty that goes beyond the private practice setting. It requires that we teach our students not only how to treat disease, but how to see injustice. Can we attest that our curricula cover this sufficiently?

Introducing structured modules on health equity, social determinants of oral health, and community engagement, supported by reflective assignments and community-based placements would go a long way toward humanising our profession. It would help students to see dentistry not as a service to the wealthy, but as a public good and a human right.

Environmental sustainability is becoming the forgotten responsibility

As the world grapples with climate change, resource scarcity, and environmental degradation, healthcare systems are being called to account, not only for how they treat disease, but also for how they contribute to planetary health. Dentistry, with its reliance on single-use plastics, heavy water consumption, energy-intensive equipment, and chemical waste, is far from exempt.

Yet despite this urgency, sustainability remains almost entirely absent from the dental curriculum. Few students graduate with even a basic understanding of the environmental footprint of dental practice. Fewer still are empowered to make changes in their clinical environments that reduce waste, conserve energy, or promote eco-friendly alternatives.

The consequences of this omission are far-reaching. As new generations of dentists enter practice without environmental literacy, they unwittingly perpetuate outdated models of care that are both wasteful and unsustainable. Sustainability is not simply a "nice-to-have", it is fast becoming a professional imperative, one that intersects with ethics, economics, and global public health.

Introducing even basic content such as green procurement practices, digital workflows that reduce material waste, or sustainable infection control protocols, could plant seeds for long-term change. Simulation clinics and clinical assessments could begin to integrate sustainability checkpoints. Regulatory bodies could begin to incentivise eco-conscious behaviour in practices and continuing professional development. Crucially, sustainability education also reinforces a broader message: that dentistry does not exist in isolation, but in a complex web of social and ecological interdependence. When students learn that small choices, like material selection, supplier partnerships, or waste segregation, can have planetary impact, they could begin to see themselves as stewards, not just service providers.

Life after graduation

Dental education often follows a narrow trajectory: undergraduate training, community service, private or public practice, and for a few, postgraduate specialisation. While this traditional pathway has served many well, it leaves little room to explore the rich and diverse career possibilities that exist beyond the clinical operatory.

Students graduate into a world where dentistry intersects with research, policy, education, technology, law, corporate consultancy, and global health. Yet, how often are these avenues presented as viable options during undergraduate training? How often are students encouraged to consider how their unique interests might translate into roles as academic scholars, medico-legal advisors, healthcare entrepreneurs, or NGO-based clinicians?

This gap in guidance not only limits student potential but contributes to burnout, dissatisfaction, and attrition within the profession. When graduates feel boxed into a singular definition of success, clinical productivity, they may struggle when life's realities or personal aspirations demand change.

In an era where artificial intelligence, teledentistry, corporate consolidation, and insurance structures are reshaping the profession, flexibility and adaptability are no longer luxuries, they are essential competencies. And yet, dental curricula often overlook the need to train graduates to pivot, to lead in non-traditional settings, or to innovate in response to systemic shifts.

Incorporating content on alternative career paths, financial planning for life transitions, and skills for lifelong learning could empower students to proactively shape their professional futures rather than reactively adapt. Mentorship programmes that include professionals outside of direct patient care, or guest lectures from dental academics, innovators, or advocates, can broaden horizons and spark new ambitions.

Preparing dental students for "life after teeth", or rather, life beyond the drill, means recognising that the value of a dental education extends far beyond clinical practice. It is a foundation for leadership, advocacy, and impact across society. Ignoring this stunts not only careers, but the growth of the profession as a whole.

Interdisciplinary collaboration and communication

Modern healthcare is no longer confined to silos. Patients are increasingly managed by teams of professionals, medical doctors, pharmacists, psychologists, social workers, speech therapists, dietitians, each contributing distinct insights toward comprehensive care. Yet dental education often lags behind in preparing students to function meaningfully within these interdisciplinary ecosystems.

The traditional image of the dentist as an autonomous practitioner, operating in isolation, is becoming outdated. Complex patient needs, such as those with chronic systemic diseases, special care requirements, or psychosocial challenges, demand a coordinated approach. Effective interprofessional collaboration is no longer optional; it is essential.

However, few dental curricula offer structured training in how to communicate across disciplines. There is limited exposure to shared decision-making frameworks, case discussions with other health professionals, or opportunities to learn the language, priorities, and scope of other fields. As a result, new graduates may feel unprepared, or worse, disinterested, in collaborative models of care.

Equally under-addressed are the soft skills necessary for managing difficult conversations. These include explaining adverse outcomes, navigating patient dissatisfaction, acknowledging errors, and responding with empathy and professionalism. While clinical competence is taught and assessed with precision, communication, particularly in high-stakes or emotionally charged situations, is often left to chance or learned through uncomfortable trial and error.

Incorporating communication theory, role-play simulations, and collaborative case management into the curriculum could begin to close this critical gap. Moreover, dental students should be explicitly taught to recognise and manage power dynamics within interdisciplinary teams, advocating confidently for their role while respecting the contributions of others.

The goal is not simply to teach students how to work *with* other professionals, but how to think like collaborative clinicians, aware, empathetic, communicative, and responsive to the holistic needs of patients. In doing so, we foster a generation of dentists who are not only technically skilled, but also emotionally intelligent and team-ready.

Why the ghost curriculum matters

The most profound lessons in dentistry often exist outside of radiographs, clinical protocols, or textbook chapters. They reside in the silent spaces between lectures, in the unspoken expectations, the unwritten rules, and the real-life complexities that challenge even the most competent practitioner. This is the realm of the *Ghost Curriculum,* the essential knowledge, skills, and attitudes that are rarely codified but deeply shape professional identity and competence.

When these invisible themes are left unaddressed, the consequences ripple far beyond academic performance. Graduates may emerge feeling clinically adept, yet psychologically unprepared, ethically conflicted, or professionally adrift. They may struggle with the loneliness of practice, the stress of financial decisions, or the dissonance between idealism and commercial reality. Others may quietly internalize feelings of inadequacy when faced with moral grey zones or uncertain career paths for which they were never prepared.

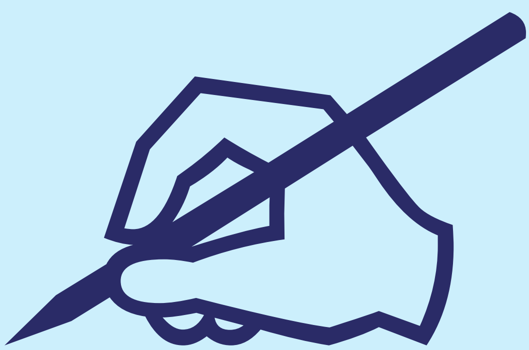
The Ghost Curriculum matters because it represents a bridge between competence and wisdom, between surviving dental practice and thriving in it. It challenges us to teach not only the “how” but also the “why” and the “what if.” In doing so, it honours the full complexity of what it means to be a healthcare professional in the 21st century.

Addressing these curricular blind spots does not require a complete curricular overhaul, but rather a shift in vision, a willingness to create space for reflection, conversation, and interdisciplinary learning. It means inviting students to engage critically with topics like mental health, sustainability, equity, business ethics, and collaborative care, not as afterthoughts, but as integral to their formation as professionals. It requires lecturers to shed complacency and start to accept responsibility for shaping the wholistic future of Oral Healthcare in South Africa.

Ultimately, the Ghost Curriculum urges educators to ask: *What kind of dentists are we graduating?* And more importantly, *what kind of human beings?*

CPD questionnaire on page 288

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.



South Africa's Dental Assistant Dilemma: Closing the Gap Between Training and Practice

SADJ JUNE 2025, Vol. 80 No.5 P237

Mr KC Makhubele – CEO, South African Dental Association

South Africa's decision to formalize dental assistant training under the Health Professions Council of South Africa (HPCSA) was intended to standardise education and elevate the profession. However, unintended consequences have emerged, including concerns about the quality of training, employability of graduates, and accessibility of programmes for those in underserved regions.

Accredited Institutions and Their Output

The HPCSA accredits several institutions to train dental assistants, including: Central University of Technology, Free State; Durban University of Technology; Tshwane University of Technology; Cape Peninsula University of Technology.

Collectively, these institutions graduate hundreds of dental assistants each year, yet clinics – particularly those in remote areas – struggle to fill positions. This suggests a geographic mismatch, where graduates prefer staying in urban centres, leading to oversaturation in some regions and shortages in others.

Declining Practical Skills Among Graduates

SADA has also observed that newly qualified dental assistants often lack essential practical skills, despite having completed formal training. While they grasp basic theoretical concepts, up to date knowledge and hands-on expertise seems limited in some cases, raising concerns about whether current training sufficiently prepares them for real-world clinical environments.

Outdated Curriculum and Industry Alignment?

Dental practices evolve rapidly, yet questions remain about whether training institutions have updated their curricula to reflect modern technology and best practices. If course content has remained unchanged since inception, it may no longer align with industry needs. Institutions must regularly revise their programmes to ensure relevance.

Are Training Institutions Recruiting the Right Candidates?

Another concern is whether institutions attract students genuinely interested in the profession or those seeking a quick certification. If students enrol without a true commitment to the field, it contributes to high professional attrition rates and an underwhelming skill set in the workforce.

Breaking the Training-to-Employment Disconnect

Despite an annual influx of graduates, many dental clinics struggle to find competent assistants. Key reasons may include:

- Insufficient Practical Training – Many graduates lack real-world experience, making their transition into employment difficult.
- Geographic Imbalance – Graduates often avoid working in rural areas, where their skills are most needed.
- Mismatch Between Training and Job Market Needs – The curriculum may not equip students with the competencies required for immediate integration into dental practices.
- Solutions – Strengthening the Dental Assisting Profession.

To bridge the gap between training and practise, a multi-faceted approach is needed:

- Curriculum Modernization – Training programmes must be regularly updated to reflect technological advancements and evolving industry standards. The HPCSA should collaborate with dental associations and training institutions to ensure relevance.
- Enhanced Practical Training – More clinical hours and hands-on training in diverse dental settings should be mandated to improve graduate competency.
- Improving Geographic Workforce Distribution – Incentives, such as bursaries or loan forgiveness, should encourage graduates to work in underserved areas.
- Selective Admission Criteria – Institutions should implement job-shadowing requirements before enrolment to attract genuinely committed students.
- Stronger Industry Collaboration – Universities and colleges must work closely with dental clinics and industry stakeholders to align training with job market demands.
- Expanding Access Through Online Training.

The concentration of dental training institutions in urban centres limits access for students from remote areas. Universities should integrate online learning into their programmes, allowing students to complete theoretical coursework remotely while partnering with local clinics for practical training.

Benefits of this model include:

- Greater Accessibility – Students in rural areas can train without relocating.
- Improved Workforce Distribution – Graduates are more likely to work in their home regions, addressing regional shortages.
- Cost-Effective Education – Online learning reduces financial barriers for students and institutions.
- Adaptability – Programmes can be updated frequently to keep pace with industry developments.

A Call for Urgent Reform

The current training model is failing both graduates and employers. Without urgent reforms, South Africa risks deepening the shortage of skilled dental assistants despite a steady supply of newly qualified professionals. Policymakers, educators, and industry stakeholders must act swiftly to modernize training, enhance practical exposure, and expand access to education – ensuring the profession thrives and meets the country's oral healthcare needs.

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Climate Change and Tuberculosis – A Growing Global Health Threat

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R Ahmed

As the global climate continues to shift in unprecedented ways, its far-reaching impacts are being felt not only in ecosystems and economies but also in public health. Among the growing concerns is the emerging link between climate change and tuberculosis (TB), a connection that is gaining increasing attention in global health discourse. Scientific research suggests that climate change may significantly influence the incidence, transmission, and control of TB by exacerbating environmental, social, and health-related risk factors.

Extreme weather events – such as heatwaves, floods, and droughts displace communities and drive people into overcrowded shelters and informal urban settlements. These conditions, marked by poor ventilation and limited healthcare access; provide fertile ground for TB transmission. Rural-to-urban migration, often climat e-induced; intensifies urban overcrowding and creates public health challenges in already strained environments.

Climate change also contributes to poverty and food insecurity, both of which are linked to higher TB risk. Crop failures and rising food prices reduce access to adequate nutrition, particularly in low-income communities. Malnutrition weakens immune defences, making individuals more vulnerable to TB infection and its complications. Alarming projections suggest that by 2050, an additional 24 million children may be malnourished due to climate-related disruptions, significantly amplifying TB susceptibility among the most vulnerable.

Moreover, climate-related challenges can deepen existing health disparities, particularly among vulnerable populations such as infants, the elderly, and women. Limited access to nutrition, healthcare, and adequate sunlight – factors increasingly affected by environmental changes – can weaken immunity and hinder TB recovery, making these groups especially susceptible.

These interconnected challenges present a major obstacle to achieving global TB elimination targets, including the WHO End TB Strategy. To effectively address TB in the era of climate change, we must adopt a multidisciplinary, forward-thinking approach. This includes climate-resilient public health strategies, targeted interventions for high-risk populations, and strengthened health systems capable of adapting to environmental change.

South Africa carries one of the highest burdens of TB globally, ranking among the top countries with the highest incidence rates. The epidemic is deeply intertwined with the country's socioeconomic challenges, including high levels of poverty, overcrowded living conditions, and a significant prevalence of HIV co-infection, which weakens immune systems and accelerates TB progression. The dual burden of HIV and TB has strained South Africa's healthcare infrastructure, despite considerable progress in treatment access and TB control programs. These interconnected health and environmental challenges highlight the urgent need for integrated, climate-resilient approaches to TB control in South Africa.

As climate change continues to reshape health outcomes globally, its intersection with TB demands urgent attention – especially in high-burden regions like South Africa. Vulnerable groups face increasing risks, while systemic challenges threaten to widen existing gaps in care. Within this context, dentistry cannot remain on the periphery. Oral health professionals are uniquely positioned to support early detection, patient education, and community-based interventions, particularly in underserved areas. Urgent investment in interdisciplinary research, robust surveillance systems, and responsive health policy is needed to better understand and mitigate the impact of climate change on TB. For South African dentistry, this is more than a medical obligation – it is a call to action rooted in equity, resilience, and the broader pursuit of sustainable healthcare.

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Farewell Message

SADJ JUNE 2025, Vol. 80 No.5 P239

P Govan

After 28 deeply rewarding years of serving The South African Dental Association and the broader dental profession, the time has come for me to bid farewell as Head of Legal & Governance.

It has been a profound honour to walk this journey with you, advocating for the profession, supporting members through challenging times, and contributing to the ever-evolving legal and ethical landscape of dentistry in South Africa. Over nearly three decades, I have had the incredible privilege of working under four CEOs, each with unique management styles that required adaptation. I have witnessed resilience, integrity, and unwavering dedication of dental professionals across the country, and I am immensely proud to have been part of this community.

Reflecting on Our Shared Journey

I have had the incredible privilege of contributing to the landmark unity discussions amongst four dental associations, culminating in the new and unified SADA with a new structure and constitution.

Throughout these years, we have navigated significant milestones together. From the early days of strengthening a comprehensive professional indemnity framework, short term insurance products, providing guidelines and templates, to adapting to the digital transformation of our membership, we have consistently worked to ensure that South African dentistry remains at the forefront of both clinical excellence and ethical practice. I have had the privilege of contributing to policy developments, bulletins, guidelines, templates, position papers, the enhancement of protocols, that have become models for other healthcare professions.

Together, we have weathered regulatory changes, economic challenges, and the unprecedented demands of the global pandemic. We were one of the first organisations to conduct our annual meetings and other meetings electronically. Through each challenge, I have been continually inspired by the profession's commitment to patient care and professional integrity. The countless hours spent on complex legal matters, ethical consultations, and policy refinements have been made meaningful by knowing that our work directly supported practitioners in delivering exceptional care to their communities.

I am particularly proud of our collective efforts in advancing continuing professional development requirements, establishing clearer guidelines for emerging dental technologies, and creating robust frameworks for inter-professional collaboration. These achievements represent not just legal milestones, but genuine contributions to the elevation of dental practice standards across South Africa.

Gratitude and Recognition

To the leadership of SADA, thank you for your trust, your vision, and your steadfast commitment to serving the profession. Your strategic guidance and unwavering support have made it possible to address complex legal challenges with confidence and clarity. The collaborative spirit you have fostered has been instrumental in achieving so many of our shared objectives.

To the members, thank you for allowing me to be part of your professional lives and for the many moments of engagement, collaboration, and learning we have shared. Your questions, concerns, and insights have enriched my understanding of the practical realities of dental practice and have guided the development of more responsive and relevant legal guidance. The trust you placed in me during difficult professional moments has been both humbling and motivating.

To my colleagues within SADA's administrative and professional teams, your dedication and expertise have made every achievement possible. I am particularly grateful to Ms Lin Domenico for her guidance and support during the early years and for more than 10 years, Ms Noma Nkiwane in our department as well as Dr Tinesha Parbhoo. The synergy we created together has been one of the most fulfilling aspects of this role.

Looking Forward

As I step away from this role, I carry with me a deep sense of gratitude for the relationships built, the lessons learned, and the privilege of having played a part in safeguarding and strengthening the profession I respect so deeply. The legal and ethical foundations we have built together will serve as a solid platform for future growth and adaptation.

I am confident that the Association is well-positioned to continue addressing the evolving needs of the profession. The robust systems, clear precedents, and strong professional culture we have cultivated will serve both current and future members well.

May the Association continue to grow in strength and impact, and may the profession always be guided by the highest principles of care, ethics, and service. May each practitioner find fulfilment in their vital work of promoting oral health and enhancing the well-being of all South Africans.

With sincere thanks and warmest regards.

Punkaj Govan
Head Legal and Corporate Governance (Retired)
South African Dental Association

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First permanent molar root canal configurations in a South African sample: a descriptive micro-computed tomographic report

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ABSTRACT

The aim of this paper was to describe root canal configurations using micro-CT in South African first molars. A segmentation process was followed on micro-focus X-ray computed tomography (micro-CT) scans of 101 maxillary and 86 mandibular first molars. Main and accessory root canal anatomy were considered to describe root canal configurations. Intra- and inter-observer reliability was determined using the unweighted Cohen's Kappa test. Intra- and inter-rater agreement was 93% for maxillary configurations; 92.9% and 86.2% respectively for mandibular configurations. The most common main canal configurations were: $^{3}M_{X}FM\ MB^{1}DB^{1}P^{1}$ (*n* = 33/93, 35.5%) and $^{2}M^{D}FM\ M^{1\text{-}2}D^{1}$ (*n* = 8/84, 9.5%) (separate three-rooted maxillary and two-rooted mandibular respectively). The addition of accessory canals resulted in configurations that were mostly individualised with only a few notable similarities. A total of 97 unique configurations were found in maxillary teeth and 85 in mandibular teeth. In the separate three-rooted maxillary molars, the only similarities were $^{3}M_{X}FM\ MB^{1(A2)}DB^{1(A1)}P^{1}$ (*n* = 4/93, 4.3%) and $^{3}M_{X}FM\ MB^{1(A1)}DB^{1(A1)}P^{1}$ (*n* = 2/93, 2.2%). In two-rooted mandibular molars, only $^{2}M_{D}FM\ M^{1}D^{1}$ (*n* = 2/84, 2.4%) was noted. Root canal configurations were found to be diverse and complex.

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Keywords

Accessory canals, first molars, micro-CT, root canal configurations

Introduction

The basis of successful endodontic treatment outcomes is a sound knowledge of root and canal morphology.[1] Failure to identify and disinfect all areas of a root canal system may result in treatment failure.[2] The root canal configurations in first molars have been shown to be complex with differences between sex, populations and variations between geographic distributions.[3-6]

With the advent of new imaging modalities, a clearer understanding of the root canal system has now been discerned. While cone-beam computed tomography (CBCT) is advantageous for its clinical applications and investigation of root and canal morphology, it is difficult to identify complex root canal morphology and accessory canals unless they are large enough to be visualised.[7] Because of its high resolution, micro-focus X-ray computed tomography (micro-CT) has been suggested and confirmed as the most appropriate modality to focus on fine detail, often not detected or visible using other investigative methods.[8,9]

Root canal configurations can form an integrated component of treatment planning and execution during retreatments or planned apical surgery.[10] To allow some degree of predictability, investigators attempted to identify common

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configurations using a classification systems. Recently, Ahmed and co-authors suggested a classification system along with guidelines and terminology for CBCT and micro-CT scans.[7,11,12] This system made provision for the inclusion of complex root and canal morphologies in a clear and understandable manner.[12,13] The system has gained popularity from researchers and undergraduate teaching institutions worldwide.[11,14] As researchers and clinicians, it is important to consider all relevant root and canal morphology.[1] To date, the research available on the mandibular first molars of South Africans is limited, with most authors using CBCT on mixed or undisclosed populations.[15-18] One South African CBCT study, using the Vertucci classification system with modifications from Sert and Bayirli[19] reported that configurations were diverse, but accessory canals or other canal complexities were not considered.[20] The objectives of this study are to report on root canal configurations of maxillary and mandibular first permanent molars using the Ahmed *et al.* classification system and micro-CT technology.

Materials and Methods

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Health Sciences, University of Pretoria (Protocol number: 298/2020). The study design was quantitative, descriptive, cross-sectional and observational and reporting followed the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines[21] (Figure1).

The methodology of this project was based on previous work by Jonker *et al.*[18,22] Additionally, the configurations in fused roots was further described as follows: separate root canal (/) or shared root canals (//). For describing configurations, maxillary first molars were allocated the code M_XFM and mandibular first molars M_DFM to avoid confusion between teeth from different arches. All scans were anonymously analysed with no prior knowledge of arch side, age or sex of the sample.

Origin of scans

Human skulls with known age, sex and population affinity were sourced from the Human Osteological Research Collection (HORC) housed in the Anatomy and Histology Department of the Sefako Makgatho Health Sciences University (Pretoria, South Africa) and the Pretoria Bone Collection (PBC) housed in the Department of Anatomy of the University of Pretoria (South Africa).[23] Permission for research was provided by family members of deceased individuals and ultimately these bodies form part of the whole body donation programme. In cases of third-party donations, the Director General, in conjunction with the Health Officer, provided authorization for research purposes. The use of all bodies in research and education is stipulated in the National Health Act 61 of 2003 (amended in 2013).

Scanning of skulls took place at the South African Nuclear Energy Corporation (Necsa, Pelindaba, South Africa) using the Nikon XTH 225L industrial CT system (Nikon Metrology, Leuven, Belgium) micro-focus X-Ray computed tomography scanner and the following settings: 100 kV voltage, 100 mA current and 2.00 seconds exposition time per projection, x-ray unit with a spot size ranging between 0.001 and 0.003 mm (1 - 3 µm), a rotation accuracy to 1/1000th of a degree of the translation table and a pixel size of 200 µm x 200 µm. The Perkin Elmer detector of the unit has a 400 mm x 400 mm field of view; an estimated 200 mm x 200 mm field of view was used to scan each maxilla or mandibulae.[24] After completion of scanning, two-dimensional projection images were reconstructed with the Nikon CT Pro version 4.4.3 software (Nikon Metrology) into 3D volumes. Isotropic voxel size/scan resolutions ranged between 40.3 µm and 74.2 µm. The final step involved the importation of the final 3D volumes into Avizo 2019 3D visualization software (Thermo Fisher Scientific Inc.) for the subsequent post-acquisition processes.[25]

Segmentation, alignment and image acquisition

Using the Isosurface module of the Avizo 2019 software, each micro-CT scan was rendered in 3D. Each maxillary first molar was virtually extracted by cropping and segmenting each scan. The cemento-enamel junction (CEJ) was used as a readily identifiable reference for the placement of landmarks on each tooth.[26] For both maxillary and mandibular molars, landmarks were placed at the highest occlusal point of the CEJ for each root on the buccal and palatal or lingual surfaces.

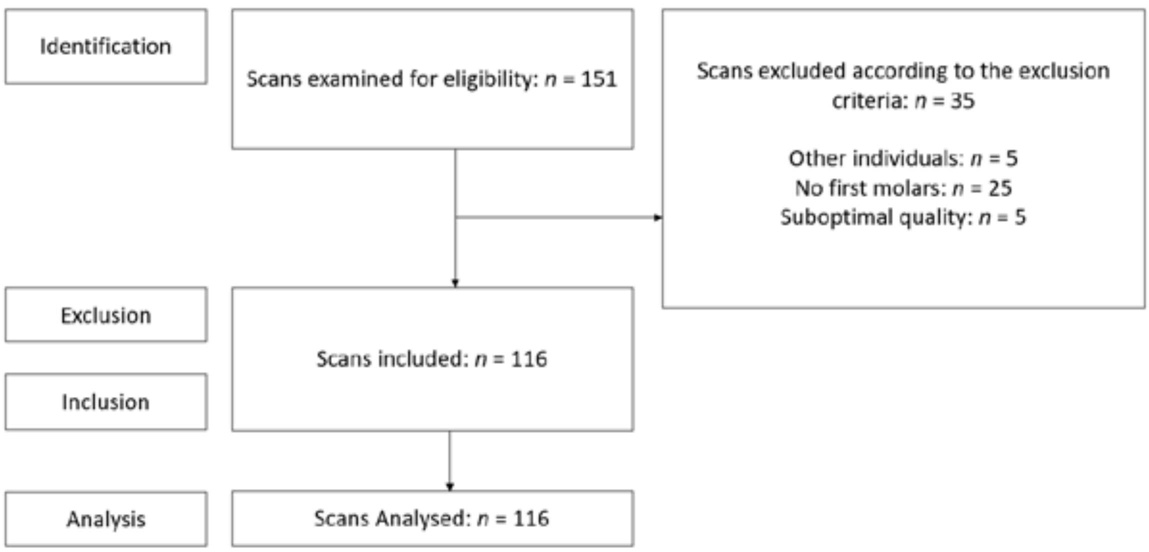

Figure 1: STROBE flow diagram to determine eligibility of available scans.

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The Avizo 2019 software can automatically compute a best-fit plane at the level of the CEJ based on these landmarks, which was used as a reference to re-align the micro-CT image stacks. The introduction of oblique sections and possible bias was reduced by repeating the same steps for each scan. The image brightness, contrast and sharpness parameters were then adjusted within Avizo for optimal visualization. The same settings were duplicated for each scan to ensure standardization.

By using the watershed method (region-based semi-automatic segmentation procedure), a virtual extraction and 3D observation of the root canal network was made possible.[27] Segmentation is a process in which each tooth and its inner components (enamel, dentine and pulp) are virtually isolated from each other. Different colours were allocated to each tooth component to allow differentiation between components. A masking or multiple slice edit procedure[28] was followed to carefully edit and correct slices where teeth had dentinal cracks in communication with the pulpal space or exterior spaces beyond the roots.

Scan analysis

Scan analysis and data capturing followed a similar methodology as previously described by Jonker *et al.*[22] Unique codes were allocated to each scan and data capturing was completed anonymously. For each scan, the pulps were isolated, magnified and rotated accordingly using the settings and parameters within Avizo. The same process was followed for each scan. Configurations of teeth with fused roots were described following the Ahmed *et al.*[7,29] and Zhang *et al.*[30] criteria. Teeth with C-shaped canals were described according to the Fan *et al.*[31] criteria and the presence of the radix entomolaris (RE) according to the criteria stipulated by Song *et al.*[32] Root canal bifurcations were identified based on descriptors and illustrations by Xu *et al.*[33]

The root canal configurations of all teeth in the sample were firstly calculated and recorded by the main researcher, an experienced operator in the field of endodontics and micro-CT. The guidelines and terminology as described by Ahmed *et al.*[7,12,13] were followed. The following figures (Figures 2 and 3) provide a summarised, descriptive illustration of the nomenclature of the Ahmed *et al.* system for root canal pathways, accessory canals, chamber canals and apical deltas used in this project.
A second researcher, a specialist and consultant in prosthodontics with experience in endodontics, participated in an inter-observer reliability test. Prior to the test, both researchers were calibrated. This calibration consisted of a consensus opinion of the guidelines and criteria of the Ahmed *et al.* classification system by evaluating two

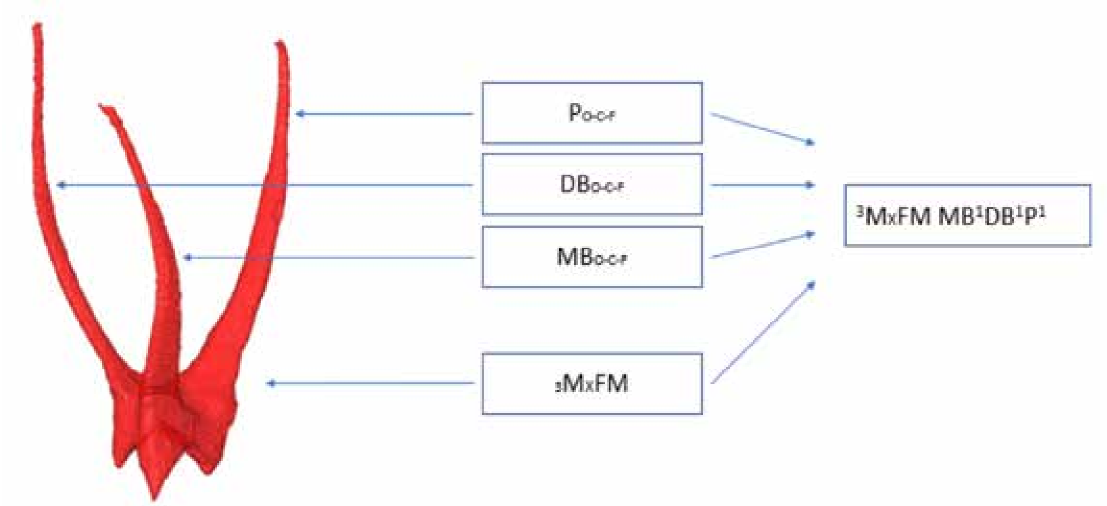

Figure 2: Three-dimensional model of the pulp extracted from a three-rooted maxillary first molar from the current study, with one root canal in each of the mesiobuccal (MB), distobuccal (DB), and palatal (P) roots. A single code is used to describe the number of roots as indicated by a superscript at the front or left of the configuration. To the right of tooth number or code, the letters O (orifice), C (canal) and F (foramen) are used for each root configuration as shown above.

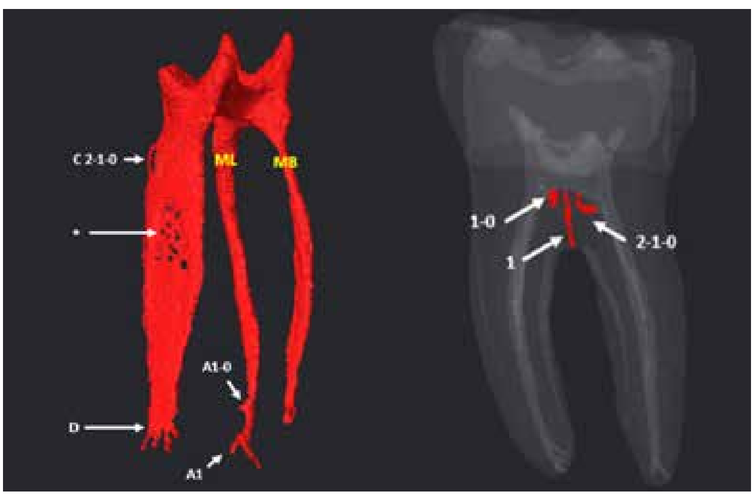

Figure 3: Classification of accessory canals and chamber accessory canals according to Ahmed *et al.* [12, 13] Left: 3D model of a mandibular first molar with C (2-1-0), a looped accessory canal in the coronal third of the distal canal; A (1-0), a blind-ended accessory canal in the apical third of the mesiolingual (ML) canal; and A (1), a patent accessory canal in the apical third of the ML canal. No accessory canals are present in the mesiobuccal (MB) canal. * indicates the presence of complex mesh-like connections in the coronal to midroot area of the distal root canals. Right: 3D model of a mandibular first molar in semi-transparency and showing examples of chamber accessory canals marked in red which have been added to the image for illustrative purposes: looped (2-1-0), blind-ended (1-0) and patent (1).

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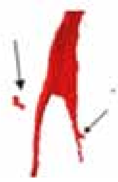
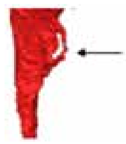
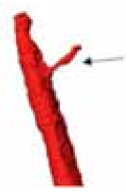
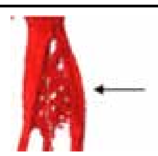
The terminology that was developed and used for this study is summarized in the glossary of terms (Table I).

Table I: Glossary of terms.

Root canal bifurcation	Divisions of the original main canal into two separate branches where the terminating branches have similar size and diameter	
Two canals with isthmus from coronal to apical	Two joined canals that appear like a single ribbon-shaped/flat canal but a root canal bifurcation is present at the apical third	
Blind accessory canal	Rod, spike, or fan-shaped root canal branches extending markedly from the main canal and follow an interrupted pathway enroute to the exit on the external root surface	
Loop accessory canal	Semi-lunar root canal located on the lateral aspect of the main canal, with a relatively smaller diameter where both ends are connected to the main canal	
Patent accessory canal (excluding chamber canals)	Root canal branches located in either the coronal, midroot or apical region that deviates from the main canal in any direction exiting on the external root surface	
Apical delta (apical ramifications)	Division of the main canal into multiple accessory canals (more than 2) and where all the accessory canals are located in the apical third independent of their distance from the apex	
Complex root canal connections (*)	Root canals that are connected by multiple intercanal communications resulting in a multi-digit Ahmed *et al.* configuration (more than 6 digits) or a mesh-like network of intercanal communications	

randomly chosen scans unrelated to the main test. During the main reliability test, the two researchers completed calculations of configurations independently and results were compared. Configurations were accepted in the event of agreement and any discrepancies in results were discussed until consensus was reached. Inter- and intra-rater reliability were determined

Inclusion criteria

The highest possible resolution scans (no blurring or double images) of self-identified South Africans of African descent with intact roots and fully developed apices, where the pulpal space could be accurately isolated were included.

Exclusion criteria

Teeth with incomplete root formation, root fractures, coronal or radicular resorption, existing root canal treatments, extensive decay obstructing any root canals, metallic restorations, scans of suboptimal quality and other self-identified population groups were excluded.

Sample size

A convenience sampling method was used from available maxillary and mandibular scans (n = 151) to limit selection bias. After consideration of the inclusion and exclusion criteria, the final selection of teeth included 101 maxillary and 86 mandibular first molars from a total of 116 scans from

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87 individuals (48 males and 39 females). Slightly more teeth from the right side (53 maxillary and 44 mandibular molars) than the left (48 maxillary and 42 mandibular molars) was identified. More males (50 maxillary and 48 mandibular) than females (51 maxillary and 38 mandibular) were included in the sample. Ages ranged between 20 and 89 years.

Statistical analysis

Statistical analysis was performed with R Statistical Software version 4.1.1 (R Core Team 2021, Vienna, Austria). For all tests, a significance level of 5% ($p < 0.05$) was selected. Intra- and inter-observer reliability and agreement were assessed using a randomly selected sample of approximately 20% of the total sample size (n = 37/187, including 20 maxillary and 17 mandibular molars). Percentages of agreement were determined using unweighted Cohen's Kappa tests.

Results

Sample characteristics and examiner agreement

The intra-rater analysis between the two rounds of calculations for the maxillary molars revealed a 93% agreement, which was confirmed by unweighted Cohen's Kappa ($k = 0.93$, $z = 8.14$, $p < 0.001$). For mandibular molars, a 92.9% agreement between rounds was achieved ($k = 0.929$, $z = 9.27$, $p < 0.001$) according to unweighted Cohen's Kappa. Regarding the inter-observer reliability for the maxillary molars, a 93% agreement was achieved between raters confirmed by unweighted Cohen's Kappa ($k = 0.93$, $z = 8.14$, $p < 0.001$). For the mandibular molars, an 86.2% agreement was achieved between raters using unweighted Cohen's Kappa ($k = 0.862$, $z = 7.91$, $p < 0.001$).

Main root canal configurations according to the Ahmed *et al.* classification.

Maxillary first molars with separate roots

Findings are summarized in Table II. Ninety-three maxillary first molars with separate roots showed a total of 33 different configurations. The most common configuration was ^{3}M$_{X}$FM MB^{1}DB^{1}P^{1} (n = 33/93, 35.5%) indicating that a single canal is present in each of the three roots with a single orifice, pathway, and apical exit (O-C-F). The next most common configurations were ^{3}M$_{X}$FM MB$^{1\text{-}*\text{-}2}$DB^{1}P^{1} (n = 7/93, 7.5%), ^{3}M$_{X}$FM MB$^{1\text{-}2}$DB^{1}P^{1} (n = 7/93, 7.5%) and ^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}1}$DB^{1}P^{1} (n = 6/93, 6.5%). A total of 22 individualized configurations were present, each representing 1.1% of the three-rooted sample (n = 1/93; 1.1%). A single tooth was identified with taurodontic traits (n = 1/93; 1.1%).

Maxillary first molars with fused roots

Findings are summarized in Table III. Eight maxillary first molars were observed where roots displayed fusion, with a total of eight different configurations, i.e., no notable patterns were identified. In five of the teeth with fused roots, the root canals were joined (//) and shared between roots (n = 5/8; 62.5%). The most common type of root fusion was type 3 (n = 5/8, 62.5%) including one tooth with an enamel pearl (EP) (n = 1/8; 12.5%). In two teeth, a type 1 fusion with joined root canals were noted, including one with a

Table II: Root canal configurations of separate three-rooted maxillary first molars according to Ahmed *et al.* excluding accessory canals, deltas, or pulp chamber canals (main canals only).

Configuration	Number of teeth	Cumulative total (number of teeth)	Total percentage (%)
^{3}M$_{X}$FM MB^{1} DB^{1} P^{1}	33	33	35.5
^{3}M$_{X}$FM MB$^{1\text{-}2}$ DB^{1} P^{1}	7	40	7.5
^{3}M$_{X}$FM MB$^{1\text{-}*\text{-}2}$ DB^{1} P^{1}	7	47	7.5
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}1}$ DB^{1} P^{1}	6	53	6.5
^{3}M$_{X}$FM MB$^{1\text{-}*\text{-}1}$ DB^{1} P^{1}	4	57	4.3
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}1\text{-}2\text{-}1\text{-}2}$ DB^{1} P^{1}	4	61	4.3
^{3}M$_{X}$M MB$^{1\text{-}2\text{-}1\text{-}2}$ DB^{1} P^{1}	2	63	2.2
^{3}M$_{X}$M ^{DA}MB$^{1\text{-}2\text{-}1\text{-}2}$ DB^{1} P^{1}	2	65	2.2
^{3}M$_{X}$FM MB^{1} DB^{1} P^{1}	2	67	2.2
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}1}$ DB$^{1\text{-}2\text{-}1}$ P^{1}	2	69	2.2
^{3}M$_{X}$FM ^{DA}B$^{1\text{-}2}$ DB^{1} P^{1}	2	71	2.2
^{3}M$_{X}$M MB$^{1\text{-}2\text{-}1\text{-}2}$ DB^{1}P^{1}	1	72	1.1
^{3}M$_{X}$FM MB$^{1\text{-}2}$ DB^{1} P^{1}	1	73	1.1
^{3}MXFM MB$^{2\text{-}1\text{-}2}$ DB^{1} P^{1}	1	74	1.1
(T^{Meso}) ^{3}M$_{X}$FM MB$^{2\text{-}1\text{-}2}$ DB^{1} P^{1}	1	75	1.1
^{3}M$_{X}$FM MB$^{2\text{-}1\text{-}2\text{-}1}$ DB^{1} P^{1}	1	76	1.1
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}3}$ DB^{1} P^{1}	1	77	1.1
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}3\text{-}4\text{-}2\text{-}1}$ DB^{1} P^{1}	1	78	1.1
^{3}M$_{X}$FM MB$^{2\text{-}1\text{-}2\text{-}3\text{-}2\text{-}1}$ DB^{1} P^{1}	1	79	1.1
^{3}M$_{X}$FM MB$^{1\text{-}*\text{-}3}$ DB^{1} P$^{1\text{-}*\text{-}1}$	1	80	1.1
^{3}M$_{X}$FM MB$^{1\text{-}2\text{-}3\text{-}2\text{-}1}$ DB^{1} P^{1}	1	81	1.1

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$^{3}M_{X}FM^{BR}\ MB^{2-1-2-1-2}\ DB^{1}\ P^{1}$	1	82	1.1
$^{3}M_{X}FM\ MB^{1-2-1-2-1}\ DB^{1}\ P^{1}$	1	83	1.1
$^{3}M_{X}FM\ MB^{1-2}\ DB^{1-2}\ P^{1}$	1	84	1.1
$^{3}M_{X}FM\ MB^{1-2-1-2-3—2}\ DB^{1}\ P^{1}$	1	85	1.1
$^{3}M_{X}FM\ ^{BR}MB^{1-2}\ DB^{1-2}\ P^{1-2}$	1	86	1.1
$^{3}M_{X}FM\ ^{DA}MB^{2}\ DB^{1-2}\ P^{1-2}$	1	87	1.1
$^{3}M_{X}FM\ MB^{2-*-2}\ DB^{1}\ P^{1}$	1	88	1.1
$^{3}M_{X}FM\ ^{DA}MB^{1-2-3-2}\ DB^{1-2-1-2}\ P^{1-2}$	1	89	1.1
$^{3}M_{X}FM\ MB^{2-*-2}\ DB^{1}\ P^{1-2}$	1	90	1.1
$^{3}M_{X}FM\ ^{DA}MB^{2-3-2-3}\ DB^{1-*-2}\ P^{1}$	1	91	1.1
$^{3}M_{X}FM\ MB^{2}\ DB^{1-*-3}\ P^{1}$	1	92	1.1
$^{3}M_{X}FM\ MB^{1}\ DB^{1-2}\ P^{1}$	1	93	1.1
Total	**93**	**93**	**100**

C-shaped configuration. A single tooth with a type 2 root fusion with joined root canals was also identified (n = 1/8; 12.5%). The remaining eight teeth displayed separated (/) root canal systems in each of the roots (n = 3/8; 37.5%).

To illustrate high dental root variation within South Africans, figures 4 and 5 below display a challenging clinical case of a South African individual where a maxillary first molar with a type 3 fusion was endodontically treated. Awareness of the possibility of highly variable root and canal morphology led a successful treatment outcome with apical healing (Figure 5 K and L):

Mandibular two-rooted first molars

Findings are summarized in Table IV. A total of 84 mandibular two-rooted first molars were analysed, with 52 different configurations calculated, and of this number, 39 were individual configurations (only one tooth per configuration,

Table III: Root canal configurations of fused three-rooted maxillary first molars according to Ahmed *et al.* excluding accessory canals, deltas, or pulp chamber canals (main canals only).

Configuration	Number of teeth	Cumulative total (number of teeth)	Percentage (%)	Separate (S) or joined (J) root canal network
$(RF^{3})\ ^{3}M_{X}FM\ ^{DA}MB^{1-2-3}\ DB^{1-*-2}/P^{1-2}$	1	1	12.5	S
$(RF^{3})\ ^{3}M_{X}FM\ MB^{2-1-2}\ DB//P^{1-*-2}$	1	2	12.5	J
$(RF^{3})\ ^{3}M_{X}FM\ MB^{2-1-2}\ DB^{1}/P^{1}$	1	3	12.5	S
$(RF^{2})\ ^{3}M_{X}FM\ MB//P^{1-2}\ DB^{1}$	1	4	12.5	J
$(RF3, EP)\ ^{3}M_{X}FM\ MB^{1}\ DB^{1}/P^{1}$	1	5	12.5	S
$(RF^{1})\ ^{3}M_{X}FM\ ^{DA}MB//DB^{1-2-3}\ P^{1}$	1	6	12.5	J
$(CsC^{1}, RF^{1})\ ^{3}M_{X}FM\ ^{DA}MB//DB^{1-*-3}\ P^{1}$	1	7	12.5	J
$(RF^{3})\ ^{3}M_{X}FM\ MB^{1}\ DB//P^{1-2}$	1	8	12.5	J
Total	**8**	**8**	**100**	

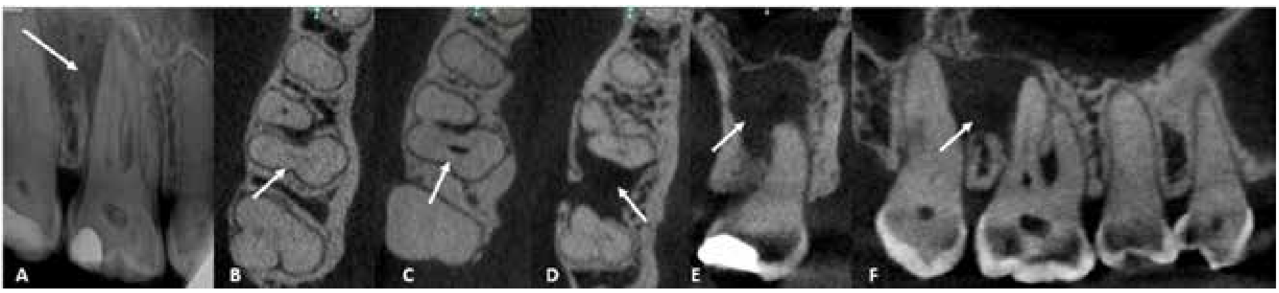

Figure 4: A 39-year-old female patient presented with a non-vital right maxillary first molar; **(A)** Pre-operative periapical radiograph showing evidence of a periapical lesion on the distal aspect of the disto-buccal root (arrow); **(B)** A coronal axial slice from a high-resolution CBCT scan revealed that the disto-buccal root and the palatal root were fused together, with evidence of two canal orifices (arrow) (disto-buccal and palatal) at this level; **(C)** A mid-root axial slice of the CBCT scan demonstrated that the two canals merged into one large canal (arrow); **(D)** An apical axial slice of the CBCT scan illustrated that the merged root still contained a single canal, with a significant area of bone destruction (arrow) extending up to the mesio-buccal root of the vital second molar. The lesion also extended at this level, resulting in the destruction of the cortical buccal plate; **(E)** A coronal slice of the CBCT scan of the fused root showed extensive bone destruction surrounding the root (arrow); **(F)** A sagittal slice of the CBCT scan illustrated the extent of the bone destruction between the fused root and the mesio-buccal root of the second molar (arrow) (clinical case courtesy of Prof. PJ van der Vyver).

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Figure 5: (G) A periapical radiograph illustrating the determination of the lengths of the two root canal systems. It was noted that the apex of the fused root canal system was open beyond an ISO size of 55, and it was decided to use Mineral Trioxide Aggregate (MTA) (Dentsply Sirona) for apex closure in this root; **(H)** A periapical radiograph confirming the fit of the ProTaper Ultimate F2 gutta-percha cone (Dentsply Sirona) in the mesio-buccal root canal system, as well as the stainless steel plugger in the fused root canal system, indicating the level where MTA will be packed (after root canal preparation with the ProTaper Ultimate system (Dentsply Sirona): the fused canal with ProTaper Ultimate FXL and the mesio-buccal root canal system with ProTaper Ultimate F2; **(I)** A post-obturation periapical radiograph following irrigation and obturation of the mesio-buccal root canal system using the continuous wave of condensation technique. MTA was packed into the apical 6 mm of the fused canal system; **(J)** The final post-obturation periapical radiograph following the obturation of the rest of the fused canal with gutta-percha; **(K)** A postoperative periapical radiograph taken after 8 months, demonstrating good healing of the periapical lesion; **(L)** A sagittal slice of the CBCT scan illustrated good healing of the periapical lesion (arrow) after 8 months (clinical case courtesy of Prof. PJ van der Vyver).

n = 39/84, 46.4%), and 13 configurations occurred in more than one tooth. The most common configurations were $^{2}M_{D}FM\ M^{1-2}\ D^{1}$ (*n* = 8/84, 9.5%), followed by $^{2}M_{D}FM\ M^{1}\ D^{1}$ (*n* = 6, 7.1%), $^{2}M_{D}FM\ M^{1-2-1-2}D^{1}$ (*n* = 4/84, 4.8%) and $^{2}M_{D}FM\ M^{1-*-1}D^{1}$ (*n* = 4/84, 4.8%).

To illustrate the high degree of variability within the root canal system within South Africans a mandibular first molar figure 6 below display a challenging clinical case of a South African individual where a mandibular first molar with a $^{2}MDFM\ M^{2}D^{1-2-3}$ configuration was endodontically treated:

Table IV: Root canal configurations of two-rooted mandibular first molars according to Ahmed *et al.* excluding accessory canals, deltas, or pulp chamber canals (main canals only).

Configuration	Number of teeth	Cumulative total (number of teeth)	Total percentage (%)
$^{2}M_{D}FM\ M^{1-2}\ D^{1}$	8	8	9.5
$^{2}M_{D}FM\ M^{1}\ D^{1}$	6	14	7.1
$^{2}M_{D}FM\ M^{1-2-1-2}\ D^{1}$	4	18	4.8
$^{2}M_{D}FM\ M^{1-*-1}\ D^{1}$	4	22	4.8
$^{2}M_{D}FM\ M^{2-1}\ D^{1}$	3	25	3.6
$^{2}M_{D}FM\ M^{1-2-1-2-1}\ D^{1}$	3	28	3.6
$^{2}M_{D}FM\ ^{DA}M^{1-2}\ D^{1}$	3	31	3.6
$^{2}M_{D}FM\ M^{1-*-2}\ D^{1}$	3	34	3.6
$^{2}M_{D}FM\ ^{DA}M^{1-*-2}\ D^{1}$	3	37	3.6
$^{2}M_{D}FM\ ^{DA}M^{1-2-1-2}\ D^{1}$	2	39	2.4
$^{2}M_{D}FM\ M^{1-2-1}\ D^{1}$	2	41	2.4
$^{2}M_{D}FM\ M^{2-*-2}\ D^{1}$	2	43	2.4
$^{2}M_{D}FM\ ^{DA}M^{1-*-3}\ D^{1-2}$	2	45	2.4
$^{2}M_{D}FM\ ^{DA}M^{2-*-2}\ D^{1}$	1	46	1.2
$^{2}M_{D}FM\ M^{2-1-2}\ D^{1}$	1	47	1.2
$^{2}M_{D}FM\ M^{2-1-2}\ D^{1}$	1	48	1.2
$^{2}M_{D}FM\ M^{1-*-2}\ D^{1-2}$	1	49	1.2
$^{2}M_{D}FM\ ^{DA}\ M^{1-*-2}\ ^{DA}\ D^{1-2}$	1	50	1.2
$^{2}M_{D}FM\ M^{1-*-3}\ D^{1}$	1	51	1.2
$^{2}M_{D}FM\ M^{2}\ D^{1-2-1-2}$	1	52	1.2
$^{2}M_{D}FM\ ^{BR}\ M^{1-2}\ ^{DA}\ D^{1-*-3}$	1	53	1.2
$^{2}M_{D}FM\ M^{2-3-2}\ D^{1}$	1	54	1.2
$^{2}M_{D}FM\ ^{DA}M^{2-1-2-3-2}\ D^{1-2-1}$	1	55	1.2
$^{2}M_{D}FM\ M^{1-2-1-2}\ D^{1-2}$	1	56	1.2
$^{2}M_{D}FM\ ^{BR}\ M^{2}\ ^{DA}\ D^{1-*-3}$	1	57	1.2
$^{2}M_{D}FM\ M^{1-*-1}\ D^{1-2}$	1	58	1.2
$^{2}M_{D}FM\ ^{DA}M^{1-2-3}\ D^{1}$	1	59	1.2

$^{2}M_{D}FM\ M^{1-2-3-2-1}\ D^{1}$	1	60	1.2
$^{2}M_{D}FM\ {}^{DA}M^{1-2}\ D^{1-2}$	1	61	1.2
$^{2}M_{D}FM\ M^{1-*-1}\ D^{1-2-1}$	1	62	1.2
$^{2}M_{D}FM\ M^{1-2-1-2-1}\ D^{1-*-2}$	1	63	1.2
$^{2}M_{D}FM\ M^{1-*-3}\ D^{1-2-1-2-1-2}$	1	64	1.2
$^{2}M_{D}FM\ M^{1-2-3-4-2-4}\ D^{1-*-2}$	1	65	1.2
$^{2}M_{D}FM\ M^{2}\ D^{1-2-1}$	1	66	1.2
$^{2}M_{D}FM\ {}^{DA}\ M^{1-2-3-2-1}\ D^{1}$	1	67	1.2
$^{2}M_{D}FM\ M^{1-3-2-3-4}\ D^{1}$	1	68	1.2
$^{2}M_{D}FM\ {}^{DA}\ M^{1-2}\ D^{1-2-1-2}$	1	69	1.2
$^{2}M_{D}FM\ {}^{DA}\ M^{2-3}\ D^{2-1-2-1-2}$	1	70	1.2
$^{2}M_{D}FM\ {}^{DA}\ M^{1-3-2}\ D^{1}$	1	71	1.2
$^{2}M_{D}FM\ M^{1-3-2-1}\ D^{1}$	1	72	1.2
$^{2}M_{D}FM\ M^{1-3-2-3-2-1}D^{1}$	1	73	1.2
$^{2}M_{D}FM\ M^{2-1-2-1-2}\ D^{1}$	1	74	1.2
$^{2}M_{D}FM\ {}^{BR}\ M^{2}\ {}^{DA}\ D^{1-*-3}$	1	75	1.2
$^{2}M_{D}FM\ {}^{BR}\ M^{2-3}\ {}^{DA}\ D^{1-*-4}$	1	76	1.2
$^{2}M_{D}FM\ M^{2}\ D^{1-*-1}$	1	77	1.2
$^{2}M_{D}FM\ M^{2-1-2}\ D^{1-2-1-2-1}$	1	78	1.2
$^{2}M_{D}FM\ {}^{DA}M^{1-2-1-2-3}\ D^{1}$	1	79	1.2
$^{2}M_{D}FM\ {}^{DA}M^{1-2-3-2-3}\ D^{1-*-2}$	1	80	1.2
$^{2}M_{D}FM\ {}^{DA}M^{1-2}\ D^{1-2-3-2-1-2}$	1	81	1.2
$^{2}M_{D}FM\ M^{1-2-1-2-3}\ D^{1}$	1	82	1.2
$^{2}M_{D}FM\ {}^{DA}M^{1-*-2}\ D^{1-*-2}$	1	83	1.2
$^{2}M_{D}FM\ M^{1-*-2}\ D^{1-*-2}$	1	84	1.2
Total	**84**	**84**	**100**

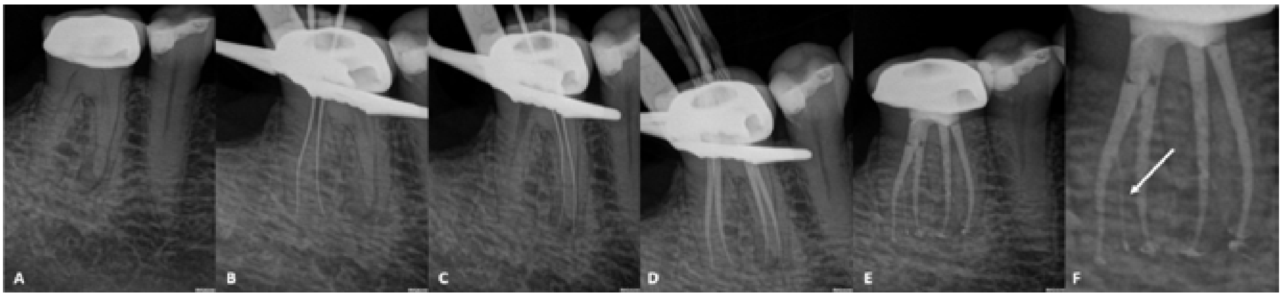

Figure 6: (A) A 45-year-old male patient presented with a non-vital right mandibular first molar; **(B)** Periapical radiograph illustrating the length determination of the two distal root canal systems; **(C)** Periapical radiograph illustrating the length determination of the two mesial root canal systems; **(D)** Periapical radiograph confirming the fit of yellow WaveOne Gold gutta-percha cones following the root canal preparation of the four root canal systems, using a yellow WaveOne Gold file; **(E)** Post-obturation periapical radiograph after irrigation and obturation of the four root canal systems via the continuous wave of condensation technique; **(F)** Note the apical bifurcation of the distobuccal root canal system in the mid-root region (arrow) (clinical case courtesy of Prof. PJ van der Vyver)..

Mandibular three-rooted first molars

Findings are summarized in Table V. In addition to the 52 configurations noted for the two-rooted mandibular first molars, two other configurations were observed in the two, three-rooted mandibular first molars evaluated. No common configurations or joined root canals were noted in the three-rooted teeth. One tooth did not have any root canal present in the additional root (n = 1/2, 50%).

Table V: Root canal configurations of three-rooted mandibular first molars according to Ahmed *et al.* excluding accessory canals, deltas, or pulp chamber canals (main canals only).

Configuration	Number of teeth	Cumulative total (number of teeth)	Percentage (%)
$(RE^{II})\ {}^{3}M_{D}FM\ {}^{DA}M^{1-*-2}\ DB^{1}\ DL^{1}$	1	1	50
$(RE^{Conical})\ {}^{3}M_{D}FM\ M^{1-*-1}\ DB^{1}\ DL^{0}$	1	2	50
Total	**2**	**2**	**100**

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Root canal configurations including accessory canals, according to the Ahmed *et al.* classification.

The addition of accessory canals to the previously calculated configurations resulted in configurations that were mostly individualised with only a few notable similarities. A total of 97 and 85 unique configurations were respectively found in the 101 maxillary and 86 mandibular teeth. In the separate three-rooted maxillary molars, the only similarities were $^{3}M_{X}FM\ MB^{1(A2)}\ DB^{1(A1)}\ P^{1}$ (n = 4/93, 4.3%) and $^{3}M_{X}FM\ MB^{1(A1)}\ DB^{1(A1)}\ P^{1}$ (n = 2/93, 2.2%). In two-rooted mandibular molars, only $^{2}M_{D}FM\ M^{1}D^{1}$ (n=2/84, 2.4%) was noted. No similarities were noted in the maxillary fused-rooted or in the mandibular three-rooted groups. For illustrative purposes to determine the root canal configuration, figure 6 below illustrates a clinical case where a mandibular first molar of a South African individual was endodontically treated. Note the presence of patent accessory canals (A1) in the apical region of the roots:

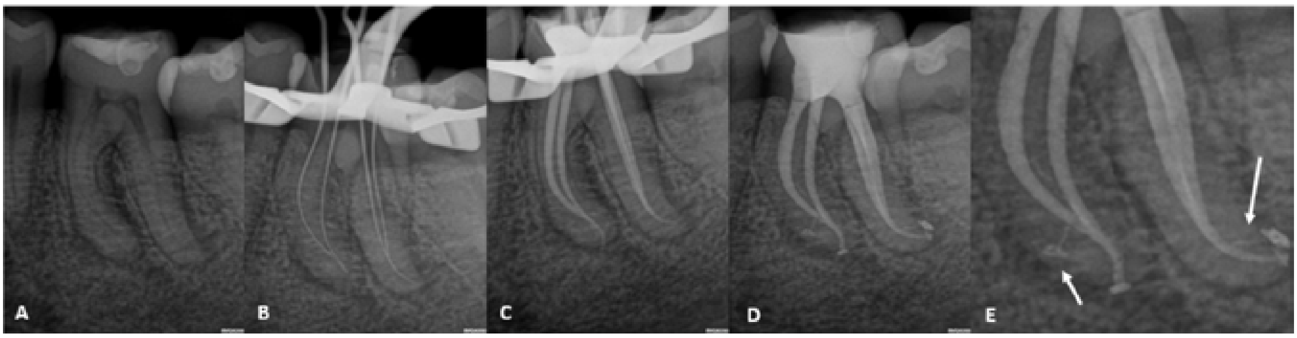

Figure 7: (A) A 52-year-old female patient presented with a non-vital two-rooted left mandibular first molar; **(B)** Periapical radiograph illustrating the length determination of the two mesial and two distal root canal systems; **(C)** Periapical radiograph confirming the fit of yellow ProTaper Ultimate gutta-percha cones (Dentsply Sirona) following the root canal preparation of the four root canal systems, using the ProTaper Ultimate system; **(D)** Post-obturation periapical radiograph indicating a $^{2}MDFM\ M^{2\text{-}1(A1)}D^{2\text{-}1(A1)}$ configuration following irrigation and obturation via the continuous wave of condensation technique; **(E)** Note the apical lateral canals in the mesial (M) and distal (D) root canal systems (arrows) (clinical case courtesy of Prof. PJ van der Vyver).

DISCUSSION

Endodontic treatment has been established as a suitable method to treat endodontically affected teeth to keep them functional and symptom-free.[1] However, root canal morphology can be extremely complex. Unfortunately, it has been shown that it can be challenging to reach and disinfect all areas of an infected root canal system.[34] Furthermore, any area of a root canal that is not disinfected has the potential to cause treatment failures.[1,35] The retention of the first molar has been recognized as important in the preservation of the occlusal scheme.[36] Unfortunately, the maxillary and mandibular first permanent molars in particular have been considered to display complex internal morphology and can pose formidable treatment challenges.[35,37]

Recently, the Ahmed *et al.* classification system, which provides clear guidelines and terminology for CBCT and micro-CT scans, was introduced.[7,11,12] Complex root and canal morphologies as well as accessory root canal anatomy can also be included.[12,13] In the current investigation, $^{3}M_{X}FM\ MB^{1}DB^{1}P^{1}$ was the most common maxillary main canal configuration (35.5%). Although the Ahmed *et al.* classification is different from the Vertucci classification system, the $^{3}M_{X}FM\ MB^{1}DB^{1}P^{1}$, $^{3}M_{X}FM\ MB^{1}DB^{1\text{-}2}P^{1}$, $^{3}M_{X}FM\ ^{(1\text{-}0)}MB^{1}DB^{1}P^{1}$, $(RF^{3},EP)^{3}M_{X}FM\ MB^{1}DB^{1}/P^{1}$, and $(RF^{3})^{3}M_{X}FM\ MB^{1}DB//P^{1\text{-}2}$ configurations calculated in this investigation indicate a single canal from orifice to apex (O-C-F) in the MB root. The combined prevalence for a single canal in a MB root (separate and fused-rooted molars) is 37.6% (n = 38/101), which is lower than the equivalent prevalence of Vertucci Type I configurations found in a Ugandan sample[5], but similar to a Russian sample[38]. The different methodologies used in these studies (CBCT and clearing/staining) and the current investigation (micro-CT) may have contributed towards the variable results.

Studies where the Ahmed *et al.* classification system were used are scarce. In a CBCT study on individuals from Chile, the authors found that the $^{2}M_{D}FM\ M^{1}\ D^{1}$ configuration was present in 13.4% of mandibular first molars.[39] In contrast to the current investigation, the same configuration was found in 7.1% in mandibular molars. The difference might be attributed to difference in population, genetics, or perhaps socio-economic factors. However, a methodological reason could also be envisioned. In the Chilean study, the landmarks used to describe the configurations were not specified, in contrast to the current investigation where the methodology of Jonker *et al.* (2024)[18] was followed. Ahmed *et al.* (2021) also highlighted the fact that results from morphological studies may be subjective, and that careful consideration should be given when comparisons are made.[7]

Even though the Ahmed *et al.* terminology considered all previous descriptions for accessory root canal anatomy, a range of pathway angles were noted by observing figures and illustrations from previous work from Ahmed *et al.*[7,13,28,29] A clear distinction between accessory canals and canal bifurcations was not described. In our investigation, it was observed that accessory canals followed a variety of angles and rarely a perpendicular pattern. This could indicate that the visual distinction between apical accessory canals and apical bifurcations based on relative angles may include a degree of subjectivity. In the current study, the relative size and diameter of the canal was used to distinguish between accessory canals and canal bifurcations and high-resolution imaging provided sufficient visual information to make the distinction. In-depth measurements and further descriptors of both accessory canals and canal bifurcations may be beneficial for consideration for future projects.

Despite the possible limitations, the current study followed a repeatable and standard method to determine the location of the orifice and the point of origin for root canal configurations based on previous work by Jonker *et al.*[18] In addition, clear guidelines were followed to distinguish between accessory canals and apical bifurcations, and between single or double canals connected with an isthmus. Clear descriptors were also provided in the Glossary of Terms (Table I) for different types of accessory canals. The authors suggest that by following the methodology and terminology described in this study, a more accurate comparison between similar future studies is possible. The current investigation is the first study reporting on root canal configurations of main canals and complex configurations using micro-CT and the Ahmed *et al.* classification system in a South African population.

One of the benefits of the Ahmed *et al.* classification system is the fact that configurations can be adjusted to suit the purpose of a study.[7] The calculation of configurations in the current project included firstly main canals and secondly accessory root canal anatomy. Many configuration types were calculated in both maxillary and mandibular molars: 41 configurations in the maxilla and 54 in mandible for main canal pathways only. A total of 183 individualised configurations were determined, and only two common configurations were noted once fine root canal anatomy was included: one in maxillary molars and one in mandibular molars. Accessory root canal anatomy cannot be ignored as these pathways could potentially provide a direct communication between the peri-apical and peri-radicular tissues and the root canal system. Causative organisms can obtain their nutrients from these channels leading to treatment failure.[40]

Buchanan *et al.* (2023)[41], in a CBCT study on mandibular second molars in South Africans, made a similar observation on the limitations of the Ahmed *et al*. classification system. Their calculations also resulted in many configurations when using the Ahmed *et al.* classification system to report on root canal configurations. The number of configurations in the current study indicates the diverse nature of the root canal complex of first molars in South Africans, confirming what other studies have reported in other population groups.[5,19]

Modern endodontic systems can prepare root canals with remarkable speed to reduce clinical chair time[1], but considering the findings from this project, it is highly advisable to place a special emphasis on irrigation regimes. Despite tremendous advances, it is virtually impossible for current root canal instrumentation to reach all areas of the root canal system and in particular complexities. Therefore, optimal chemical and mechanical disinfection techniques are instrumental to long term survival of an affected tooth.[42] A proper three-dimensional seal of the prepared and disinfected root canal spaces is also required.[1]

Limitations of the current study include for example the sample size, as a convenience sampling method was used on an already available archived micro-CT scan collection. Further, only first molars of one population group were included and investigations on other tooth types and populations and comparisons between populations might be considered for future projects. Dried human skulls were used which present with inevitable micro-crack formation leading to possible confusion between accessory canal anatomy and micro-cracks. This limitation was addressed using a masking or multiple slice editing technique described by Ahmed *et al.* (2022).[28] Micro-CT scanning was done on the entire skeletonized maxillae and mandibulae with high voxel sizes (between 40.3 µm and 74.2 µm). It has been reported that voxel sizes on extracted teeth range between <10 µm and 30 µm.[28] At higher voxel sizes, the patency of some accessory canals may not be clearly visible. Lastly, the authors acknowledge the possibility of a degree of subjectivity in the identification of root canal anatomy.

The demonstrated root canal configurations were found to be complex and important to consider not only in the South African context but also globally. Many South Africans emigrate to other countries, including the United Kingdom and Europe. Since 2010, intra-African migrations showed the second highest increase from all regions considered and more specifically Africa-Europe migrations increased by 26.0%. According to the Mo Ibrahim Foundation[43], the number of African migrants to Europe was 40.6 million in 2020. Statistics estimate that 6% of South Africans living in the United Kingdom were from African descent.[44] More locally in South Africa, a study investigated the prevalence of emergency procedures (including root canal treatments) performed at their institution. The author determined that between 90% and 91% of their patient base are from African descent.[45] Therefore, any clinician may be required to endodontically treat a first molar of these individuals.

Root canal configurations in South Africans were found to be diverse. The Ahmed *et al.* classification system classified all main root canal configurations. However, the addition of accessory canals and fine detail significantly increased the complexity, resulting in several additional configurations. It can be speculated that similar findings might exist in other populations and molars. A need has been identified to develop a classification system or propose modifications to the current Ahmed *et al*. system to accommodate complex configurations in a practical manner.

DECLARATION

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CONFLICT OF INTEREST:

None

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Managing Saliva and Surface Contamination in Dental Clinics: A Hypochlorous acid -Based Approach to Sustainable Infection Control

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ABSTRACT

Effective microbial control in dental clinics is crucial to preventing healthcare-associated infections, particularly during aerosol-generating procedures. This study evaluates the efficacy of vaporized hypochlorous acid (HOCl) in reducing microbial contamination from saliva on surfaces under various conditions. This study aligns with the Sustainable Development Goals (SDGs) by contributing to SDG 3 (Good Health and Well-Being) and SDG 12 (Responsible Consumption and Production). This novel disinfection technique promotes sustainable, eco-friendly disinfectant solutions by offering an alternative to harsher disinfectants.

Objectives

This study aimed to evaluate the antimicrobial efficacy of a vaporized HOCl based dental unit water line (DUWL) disinfectant in reducing microbial growth from whole saliva under both wet and dry conditions, across different challenge media. Secondary objectives included assessing the influence of time and medium composition on its effectiveness.

Materials and Methods

Experiments were conducted in a controlled laboratory environment. Inoculated 96-well microtiter plates were exposed to vaporized HOCl (0.005%) for two different time points, 2 hours and 24 hours. The surfaces of the microtiter plates were treated with the vaporized disinfectant under both dry and wet conditions. Microbial inhibition was assessed by measuring optical density (OD) values, which provided an indication of microbial growth and the disinfectant's efficacy at each time interval.

Results

Vaporized HOCl significantly reduced microbial contamination, especially in dry conditions, with lower OD values indicating greater efficacy. Low-nutrient media showed better disinfectant performance, while nutrient-rich media supported higher microbial growth. Longer exposure times in nutrient-rich media resulted in decreased disinfectant efficacy, emphasizing the importance of pre-cleaning.

Conclusion

Vaporized HOCl is an effective, eco-friendly disinfectant for dental clinics, with its performance influenced by medium composition and exposure time.

Keywords

Hypochlorous acid, Infection control, Sustainable disinfectants, Surface contamination, Eco-friendly disinfectants, SDG 3 (Good Health and Well-Being), SDG 12 (Responsible Consumption and Production).

INTRODUCTION

Dental clinics present unique challenges in infection control, primarily due to the frequent generation of bioaerosols during AGPs. These bioaerosols, produced from saliva and other bodily fluids, can settle on various surfaces and equipment, leading to surface contamination and increased cross-transmission risks.[1-3] Conventional methods, such as spray-and-wipe techniques and the use of disposable barriers, help reduce contamination, but there is growing interest in more sustainable solutions that can ensure both safety and environmental responsibility. HOCl emerges as a promising, eco-friendly disinfectant with broad-spectrum antimicrobial efficacy, offering a viable solution to minimize contamination risks effectively.[4]

The effectiveness of infection control strategies in dental settings relies heavily on staff adherence to stringent hygiene protocols, including regular handwashing and surface decontamination. [5,6] However, bioaerosols from saliva can linger in the clinic environment and settle on multiple surfaces, often escaping thorough cleaning between patient appointments. The high-risk occupational exposure to saliva makes dental staff particularly vulnerable to pathogens carried in saliva. Factors such as patient health, type of procedure, infection control practices, and clinic ventilation can significantly affect the potential for pathogen dissemination.[7]

Saliva droplets serve as vectors for a broad range of infectious agents, including bacteria, viruses, and fungi, that can survive for extended periods on surfaces depending on environmental conditions.[8,9] Microorganisms within saliva, such as *Streptococcus* and *Candida* species, can form biofilms on clinic surfaces, which not only make disinfection challenging but also act as reservoirs that perpetuate cross-infection risks.[10,11]

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The microbial composition within saliva varies widely across individuals and is influenced by diet, hygiene, and systemic health. [12-14] Saliva, while playing a key role in immune defence, can also facilitate biofilm formation on surfaces, complicating disinfection protocols and heightening the importance of effective surface management strategies.

The recent COVID-19 pandemic underscored the importance of mitigating saliva contamination, given SARS-CoV-2's potential to spread through salivary droplets and aerosols generated during dental procedures. [15] COVID-19 demonstrated how bioaerosols could carry viral particles over distances and allow them to linger in clinical environments, potentially compromising the safety of dental staff and patients alike. The sustainability of infection control practices became a focal point, with HOCl gaining attention as an effective, sustainable option for managing both surface and aerosolized contaminants.[16,17]

HOCl, with its ability to penetrate biofilms and eliminate both bacterial and fungal pathogens, offers a promising alternative to conventional chemical disinfectants, effectively disrupting biofilm formation while maintaining a safer profile for clinic environments. In addition to HOCl's potential benefits, the oral cavity's diverse microbiome, which includes bacteria, viruses, and fungi, presents ongoing challenges in maintaining a balanced environment within the clinic.

HOCl's efficacy in deactivating pathogens on surfaces, coupled with its ability to degrade quickly into environmentally safe byproducts, highlights its potential as a mainstay in dental clinic disinfection protocols. In the context of bioaerosol management, preprocedural mouth rinses can reduce salivary microbial load but cannot fully eliminate contaminants, underscoring the need for a complementary surface disinfectant capable of comprehensive microbial elimination. [18,19] By integrating HOCl into routine cleaning practices, dental clinics can advance towards a more sustainable approach to infection control, reducing reliance on single-use plastics and harsh chemicals while maintaining a safe clinical environment for both patients and staff. Incorporating a vaporizer to dispense HOCl offers an efficient method for achieving comprehensive surface disinfection in dental clinics.

The vaporized HOCl can reach hard-to-clean areas and delicate equipment that may not be adequately sanitized through traditional methods, reducing contamination from bioaerosols and saliva particles generated during dental procedures. Using a vaporizer to disperse HOCl as a fine mist ensures even, thorough coverage across all surfaces, including high-touch areas, and helps break down biofilms that harbor infectious agents. This approach not only enhances the efficacy of HOCl in maintaining clinic hygiene but also supports sustainable infection control by minimizing the need for excessive manual cleaning and harsh chemicals.

This study hypothesizes that vaporized HOCl can effectively reduce saliva contamination in dental clinics across both wet and dry conditions. Given the role of saliva as a major vector for microbial transmission, particularly during aerosol-generating procedures, we aim to evaluate HOCl's efficacy in managing microbial contamination on surfaces exposed to saliva. The study will assess HOCl's disinfectant performance against a range of challenge media, representing various microbial loads and environmental conditions typical of dental settings. By comparing its effectiveness across different mediums and surface states, this research seeks to establish HOCl vapor as a viable, sustainable solution for infection control in dental clinics.

In addition, this study aligns with the United Nations Sustainable Development Goals, particularly SDG 3 (Good Health and Well-Being) and SDG 12 (Responsible Consumption and Production). By evaluating the efficacy of vaporized HOCl as an eco-friendly disinfectant, the research supports the promotion of safe, sustainable healthcare practices that minimize environmental impact while enhancing infection control in dental clinics. The adoption of HOCl as a disinfectant helps reduce reliance on harsh chemicals and single-use plastics, contributing to more sustainable infection control solutions and improving the health and safety of both dental professionals and patients.

MATERIALS AND METHODS

Disinfectant and delivery

A novel approach was used in this study, where the Ultra-Low Volume (ULV) vaporizer dispensed IvoCLEAN DUWL disinfectant in vaporized form for a 1-minute exposure, followed by a 2-minute dwell time. The spray volume settings on the ULV cold fogging sprayer were set to the maximum level to ensure the widest coverage and fine particles of approximately 20 µm, as recommended by the manufacturer. This controlled method optimized the conversion of liquid into fine particles.

IvoCLEAN DUWL disinfectant, containing 0.05% anolyte HOCl at a pH of 5-7, was used. It is designed to decontaminate and remove biofilm from dental unit waterlines (DUWL) and is eco-friendly, non-toxic, and free of alcohol, formaldehyde, and bleach. For this study, the product was diluted to a 0.005% HOCl solution (1-part IvoCLEAN to 9 parts water), making it an ideal choice for surface decontamination in addition to its intended use in DUWL maintenance.

The study utilized a Neptune Portable Electric ULV cold vaporizer/fogger, which is known for efficiently converting liquid solutions into a fine mist of consistent particle size (20-50 microns). This ULV technology maximizes surface coverage, reduces disinfectant usage, and minimizes environmental impact. The vaporizer's 4-liter tank capacity prevents spills and minimizes the need for frequent refills, offering convenience and efficiency in a compact, portable design.

During exposure, 96-well microtiter plates were positioned within a fume cupboard to contain aerosols. The plates were opened at the beginning of exposure and closed after the 2-minute dwell time to ensure controlled exposure to the disinfectant. IvoCLEAN DUWL disinfectant is widely used in dental clinics for DUWL decontamination, making it an ideal product for evaluating its potential for dual use—both for cleaning DUWLs and for surface decontamination in dental environments.

Preparation of whole saliva

Whole saliva samples from two investigators, both dentists that voluntarily provided samples replicate a real-life culture scenario. The participants refrained from brushing their teeth for 24 hours prior to sample collection, which occurred in the morning after chewing paraffin wax for 5 minutes. All saliva was collected in sterile vials following infection control protocols, with any excess disposed of after the experiment. Genetic microbial identification was not performed, and only agar plate inoculation was conducted. Bacterial samples were suspended in 100ml phosphate-buffered saline, and a mixed colony was used to create a McFarland standard of 1 in phosphate-buffered saline (PBS). Standardization of the McFarland standard was achieved using a DensiCheck plus instrument.

Challenge mediums used in the study.

In this study, a range of growth mediums was utilized to evaluate pathogen behaviour and growth under controlled conditions. The challenge media used in the study were prepared according to standard protocols to replicate the variety of environments encountered in dental clinics. Distilled Water (DW), a purified, sterile medium free from salts and ions, served as a baseline control for pathogen growth without external nutrients. Phosphate-Buffered Saline (PBS), a stable salt solution, provided a pH-neutral environment that supports cell suspension without altering physiological conditions. Nutrient-rich mediums such as Yeast Peptone Dextrose Agar (YPD), Brain Heart Infusion Broth (BHI), and Tryptone Soy Broth (TSB) were included to foster microbial growth under nutrient-enhanced conditions. YPD, containing yeast extract, peptone, and dextrose, supports microbial proliferation, while BHI, derived from beef heart and brain infusions, supplies essential nutrients to sustain bacterial cultures. TSB, comprising soybean meal and casein digest, is versatile in supporting a broad spectrum of microbial species.[20] The challenge mediums that were selected to assist in understanding the basic cultivation and growth of pathogens. They don't necessarily emulate the oral cavity in its entirety, but they do allow for a controlled environment allowing for research into the characteristics of microorganisms and their response to a chemical application such as a disinfectant.

96-well microtiter plates inoculation

24-hour whole saliva isolates were standardized in phosphate-buffered saline to 1.0 McFarland. The McFarland Standards are turbidity standards used to approximate the number of microorganisms present within a liquid suspension. The cell density was adjusted to 1 McFarland standard (3×10^6 CFU/mL) by measuring absorbance in a spectrophotometer at a wavelength of 530 nm in PBS. This was followed by mixing 10ml of the 1 McFarland standard with 10ml of a challenge medium to achieve a 0.5 McFarland (1.5×10^6 CFU/mL). The challenge mediums are: 1.) DW, 2.) PBS, 3.) YPD medium, 4.) BHI medium, and 5.) TSB in flat-bottom 96-well microtiter plates. Each microorganism was placed in its individual well plate that were subdivided into the various mediums used. 10 µl of this 0.5 McFarland standard/challenge medium was placed in each well.

Image 1: Inoculation of 96- well microtiter plates

Part A: Dry challenge via dried inoculum: 96- well microtiter plates were inoculated by applying10 uL of the challenge suspension of micro-organisms to the wells, which was then kept in a sterile fume cupboard at ambient temperature overnight to allow drying of the inoculum in the wells. The inoculated wells remained closed to avoid contamination. Drying occurred in these 96-well microtiter plates at ambient temperatures. This stage of the experiment aimed to simulate scenarios of post AGP contamination, where bioaerosols settle on surfaces and dry either due to inadequate disinfection or the challenges of cleaning hard-to-reach places

Part B: Wet challenge via wet inoculum: 96-well microtiter plates were inoculated by applying 10 uL of the challenge suspension of micro-organisms in the 96 well plates. The inoculated wells remained closed to avoid contamination. This part of the experiment was aimed to simulate the surface contamination that occurs immediately after AGP.

Experimental design – fume cupboard

All experiments were conducted in a climate-controlled laboratory, maintaining an ambient temperature of 22°C ± 2°C and relative humidity between 40–60% to minimize external factors that could affect microbial growth or the stability of the disinfectant. To ensure consistency, all substrates were of the same type and size, and control groups were included to assess natural microbial growth without disinfectant exposure. These controls were subjected to the same conditions as experimental samples but without HOCl application. Additionally, the experimental setup was standardized for both wet and dry conditions to ensure comparability across groups.

The ventilated fume cupboard at the University of the Western Cape dental research laboratory was used to safely conduct the study. The fume cupboard has a volume of 900 litres and approximate dimensions of 1 meter in depth, 1 meter in width, and 0.9 meters in height. It was used to provide a controlled environment to prevent any exposure and contamination. Within the fume cupboard, the 96-well microtiter plates containing the challenge mediums were positioned securely.

Image 2: Ventilated fume cupboard in the dental research laboratory

After exposing the 96-well microtiter plates to HOCl vapor in the fume cupboard, cell viability and proliferation were assessed using the XTT assay. This colorimetric assay measures cellular enzyme activity by converting XTT to an orange formazan product, indicating metabolically active

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cells. Each well contained 100 µL of challenge medium and 50 µL of XTT solution from the Cell Proliferation Kit II (Roche Diagnostics GmbH, Mannheim, Germany). The plates were incubated for two hours, and absorbance was measured at 450 nm using a Smart Microplate Reader (Model SMR16.1, USCN Life Science Kit Inc., Wahan, China).

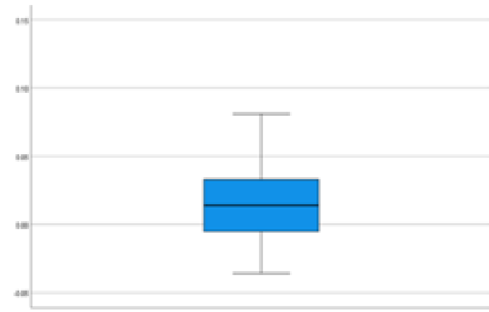
Image 3: Portable electric ULV cold vaporiser in ventilated fume cupboard

Statistical analysis was performed to assess the effects of HOCl on whole saliva across five challenge mediums by analysing optical density (OD). At least three biological replicates were tested, with triplicates for each, ensuring robust results. A Two-Way ANOVA with repeated measures was used to analyse the effects of time, medium, and their interaction on pathogen levels. Post-hoc tests, including Tukey's Honestly Significant Difference (HSD) and Scheffe tests, identified significant differences between mediums. Statistical assumptions, such as normality and sphericity, were validated using the Shapiro-Wilk and Mauchly's Test of Sphericity.

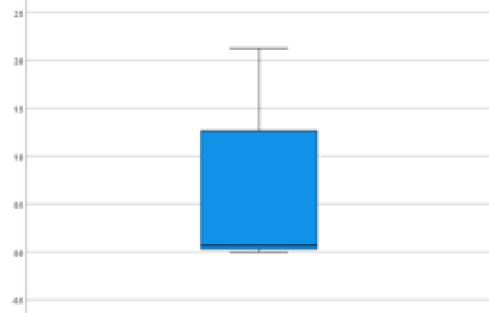
RESULTS

The graph illustrates pathogen growth in whole saliva under wet and dry conditions, showing significant growth from 2 hours to 24 hours. YPD medium consistently exhibited the highest proliferation in both conditions, with OD values increasing from 0.050 to 0.060 in dry conditions and from 0.085 to 0.227 in wet conditions. DW medium showed minimal growth, from 0.010 to 0.001 in dry conditions and from 0.01 to 0.025 in wet conditions. Overall, the wet study exhibited higher OD values at both 2 and 24 hours, suggesting greater microbial growth compared to the dry study, where HOCl was more effective in inhibiting growth.

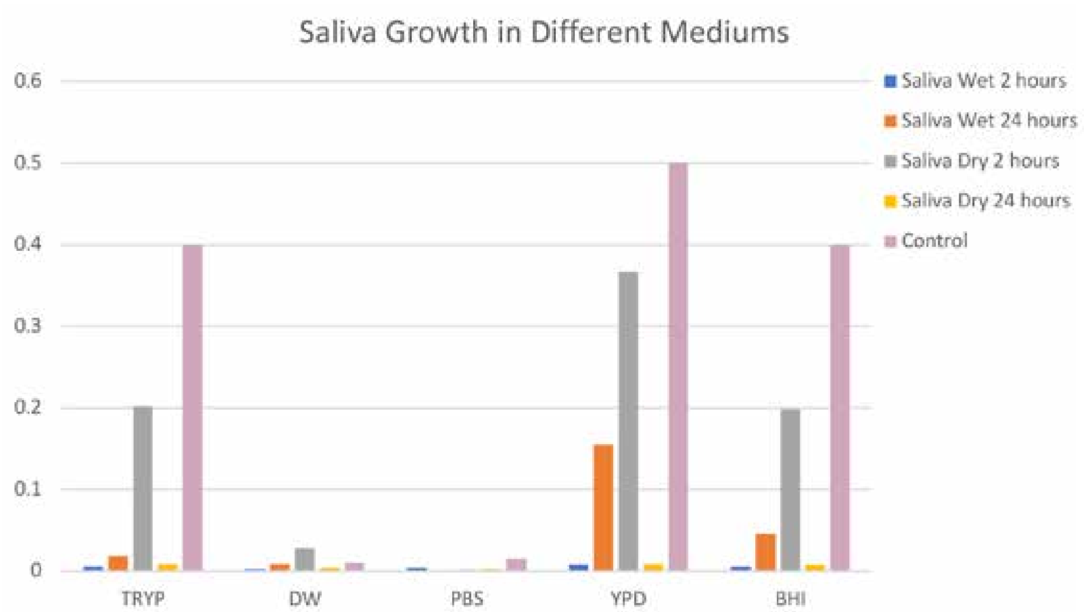
The results of the whole saliva growth study reveal significant differences in OD across dry and wet conditions, as well as between time intervals and mediums as resulted by the following graphs:



Graph 2: Effect of HOCl vapor on the whole saliva OD values after 2 hours in dry conditions.



Graph 3: Effect of HOCl vapor on the whole saliva OD values after 24 hours in dry conditions



Graph 1: The graph illustrates unidentified pathogen growth in whole saliva under wet and dry conditions, showing a significant increase from 2 hours to 24 hours.

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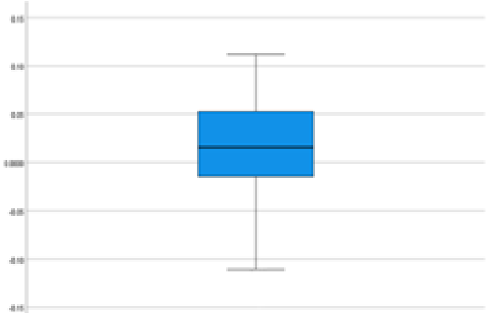
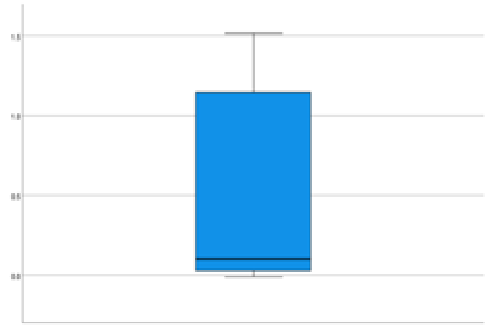
In the dry condition (Part A), there was a significant effect of time ($p < 0.001$), with OD increasing markedly from 2 hours (mean = 0.038) to 24 hours (mean = 0.863), indicating higher cell proliferation over time. The effect of medium was also significant ($p = 0.010$), with YPD exhibiting the highest OD at 2 hours, while TSB medium showed the highest OD at 24 hours, suggesting variation in medium-specific support for cell growth over time. Notably, YPD displayed consistently high OD values at both 2 and 24 hours, indicating substantial cell density.



Graph 4: Effect of HOCl vapor on the whole saliva OD values after 2hours in wet conditions



Graph 5: Effect of HOCl vapor on the whole saliva OD values after 24 hours in wet conditions

Impact of Duration (Time-Dependent Changes)

In the wet condition (Part B), time had a significant effect ($p < 0.05$), with OD increasing from 2 hours (mean = 0.006) to 24 hours (mean = 0.815). The effect of medium was also significant ($p < 0.05$), with YPD yielding the highest OD at 24 hours, followed by BHI, suggesting that nutrient-rich mediums enhance cell growth. The interaction effect further demonstrated that YPD consistently produced the highest OD across both 2 and 24 hours, indicating optimal conditions for cell proliferation.

Influence of Medium on Growth and Inhibition

In the wet study, the disinfectant had minimal effect at 2 hours in DW and PBS, with OD values similar to controls, suggesting limited growth inhibition. However, in YPD, BHI, and TSB, OD values were higher than controls, indicating reduced efficacy. By 24 hours, the disinfectant showed stronger antimicrobial effects, with OD values in all mediums lower than controls, particularly in YPD (0.227) and BHI (0.091), suggesting potent inhibition over time.

Effect of Moisture Content (Dry vs Wet Conditions)

In the dry study, the disinfectant showed minimal effect in DW and PBS at 2 hours, with OD values close to controls. However, in YPD, BHI, and TSB, slightly higher OD values were observed, indicating moderate effectiveness. After 24 hours, the disinfectant demonstrated more pronounced antimicrobial activity, with OD values higher than controls in most mediums, particularly in YPD (0.060) and BHI (0.059), indicating significant inhibition.

Comparison of Efficacy in Wet vs Dry Conditions

Comparing wet and dry conditions, HOCl was more effective in the dry study, with lower average OD values at both 2 hours (0.024) and 24 hours (0.0356). In contrast, the wet study showed higher OD values at both time points (2 hours: 0.0398, 24 hours: 0.0974). The log kill values in the dry study ranged from 0.695 to 0.954 across different mediums, indicating variable effectiveness of HOCl, with stronger inhibition in YPD, BHI, and TSB. These findings highlight the differential efficacy of IvoCLEAN DUWL disinfectant under varying environmental conditions and its potential for use in diverse disinfecting contexts.

The results of the IvoCLEAN study demonstrate that vaporized HOCl significantly reduced microbial growth, particularly in whole saliva samples, under varying experimental conditions. However, to fully understand the factors influencing this antimicrobial activity, it is crucial to explore how different challenge media and exposure times impacted the disinfectant's efficacy. Notably, the effects of time and medium composition on microbial reduction were found to vary significantly, providing insights into how the presence of organic matter and nutritional content in the medium can influence pathogen survival. These findings are essential for optimizing disinfection protocols in clinical settings, where variations in surface contamination and environmental factors are common.

Discussion

This study hypothesized that vaporized HOCl could effectively reduce saliva contamination in dental clinics under both wet and dry conditions, given the role of saliva in microbial transmission. The findings confirm this hypothesis, demonstrating that HOCl effectively reduces microbial contamination on well plates contaminated with saliva, which is a simulation of surfaces exposed to saliva in dental clinics. This result is crucial for minimizing infection risks, particularly in dental settings where aerosol-generating procedures are common. The study's experimental conditions, using various challenge media, replicate typical environmental factors in dental clinics, supporting the potential for HOCl vapor as a viable, eco-friendly solution for infection control.

Beyond its clinical benefits, this study aligns with the United Nations Sustainable Development Goals, particularly Goal 3: Good Health and Well-being and Goal 6: Clean Water and Sanitation. Ensuring effective infection control in dental clinics is essential for preventing healthcare-associated infections, directly supporting Goal 3 by safeguarding patient health and improving overall quality of care. Furthermore, by exploring environmentally friendly disinfection agents like HOCl, our research promotes sustainable practices in healthcare. HOCl represents a safer, non-toxic alternative to traditional disinfectants, reducing the risk of chemical exposure for patients and healthcare workers while contributing to the responsible management of resources in healthcare settings, as emphasized in Goal 6.

Efficacy of HOCl Concentrations in Dental Disinfection

HOCl is widely used for dental disinfection, with concentrations ranging from 0.01% to 0.1% for routine cleaning and up to 0.5% for blood contamination. Lower

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concentrations, such as 0.005% to 0.02%, are effective in dental settings for surface disinfection and reducing cross-infection risks. Aerosolized HOCl concentrations of 0.002% to 0.01% show strong antimicrobial activity. The IvoCLEAN study uses 0.005% HOCl in vaporized form, which aligns with recommendations for effectively eliminating biofilm-forming microorganisms in DUWL. This concentration offers a potent, safe approach to dental surface disinfection.

Efficacy of HOCl in Reducing Microbial Growth on Whole Saliva

The results of the IvoCLEAN study on whole saliva demonstrated that HOCl was effective in reducing microbial growth. Lower OD values were observed in dry conditions indicating greater efficacy compared to wet conditions. Over a 24-hour period, samples treated with HOCl maintained lower OD values, suggesting a lower presence of microbial contaminants and better disinfection efficacy. The effectiveness of HOCl in whole saliva is supported by literature highlighting its ability to eliminate pathogens through disruption of cellular walls, resulting in cell inactivation.[12,21-23]

Impact of Time and Medium on HOCl Efficacy in Dental Disinfection

The results concerning the impact of time and various challenge mediums are crucial for evaluating the disinfectant's efficacy. The significant effect of time provides insight into understanding what influences pathogen proliferation. The study strategically chose different mediums with varying levels of nutritional content to simulate clinical scenarios involving splatter or large bioaerosol contaminated with microorganisms, either with organic matter (from the oral cavity) or smaller aerosolized particles without organic matter. The IvoCLEAN study used a range of mediums to mimic the organic matter and biological fluids typically found in the oral cavity. DSW served as a sterile control medium, and PBS provided a stable environment for studying the behaviour of the microorganism without altering the physiological environment. YPD, TSB, and BHI were nutrient-rich mediums supporting microbial growth, by providing nutritional support, that allowed for the proliferation of the microorganism. Through the use of these mediums, realistic conditions were simulated to obtain comprehensive results into bio-decontamination processes within dental clinics.

When interpreting the results of the effect of time and medium on the efficacy of the IvoCLEAN DUWL disinfectant, the following conclusions were made. In terms of efficacy, the results indicate that low-nutrient media (like distilled water and phosphate-buffered saline) were more effective at reducing microorganism concentrations and inhibiting cellular proliferation when exposed to HOCl. This is reflected in low OD values, which are indicative of fewer viable cells. The reduced presence of nutrients likely limits the growth of microorganisms, enabling HOCl to more effectively target and deactivate them.

On the other hand, high-nutrient media (such as TSB, BHI, and YPD) supported moderate efficacy of HOCl. The slightly higher OD values suggest that these media, which are rich in nutrients, allowed for more microbial growth, despite exposure to HOCl. In wet conditions, HOCl was still effective, but the presence of additional nutrients (from these media) provided more favourable conditions for the survival and proliferation of microorganisms.

The key takeaway here is that the efficacy of HOCl as a disinfectant is influenced by the nutritional content of the medium. Media with fewer nutrients appear to be more conducive to effective microbial deactivation, while richer media can potentially support microbial growth, even in the presence of HOCl. This highlights the importance of considering the nutrient composition of environments when evaluating the effectiveness of disinfectants.[24,25]

This aligns with other studies that show how specific conditions can influence pathogen growth patterns.[26,27] Although the mediums used in this study do not directly represent the human oral cavity, they provide a controlled environment to study microbial behaviour and the impact of disinfectants.[11] In the case of YPD, the nature of the medium can serve as a surrogate for organic matter that could be present in the oral cavity, similarly with the nutrient-rich BHI. The clinical significance of these findings reiterates the need to clean effectively and remove any residual matter that may remain on surfaces in the dental clinic. [1] This will support the studies that suggest pre-cleaning and removal of visible organic matter aids in complete decontamination.[4]

The significant interaction effect between time and medium groups further highlights the dynamic relationship between environmental factors and microbial growth dynamics.[25]

The statistical findings suggest that the influence of medium groups on pathogen levels varies over time in the whole saliva experiments, since the pathogen levels differed between the 2-hour and 24-hour time points. This can be attributed to the response of the microorganism to their environment over time. The time factor result reinforces the importance of effective disinfection protocols that prevent pathogens from establishing and proliferating over time, forming biofilm.[1]

Using a vaporized form of HOCl based infection ensures comprehensive coverage of surfaces and rapid action, especially in hard-to-reach areas, which is essential for maintaining a pathogen-free environment between patients. The efficacy of HOCl in inhibiting microbial growth shows a moderate decline from its initial effectiveness at 2 hours to 24 hours across various mediums.

The efficacy of HOCl was shown to be influenced by both medium composition and moisture content. Low-nutrient mediums such as DW and PBS demonstrated consistent effectiveness, with sustained low OD values even after 24 hours, suggesting they maintain microbial inhibition over extended periods. In contrast, nutrient-rich mediums like YPD, BHI, and TSB saw a significant increase in OD values, indicating decreased disinfectant efficacy and higher microbial proliferation over time.[28,29] This highlights the crucial role of medium composition in determining the effectiveness of disinfectants, as nutrient-rich environments can support microbial growth even in the presence of disinfectants. These findings have significant implications for future research in surface contamination management.[30]

The clinical implications of these findings are significant, especially in dental settings where splatter and biofilm formation can occur on various surfaces during procedures. The study's assessment of both wet and dry conditions is critical because dental splatter can vary in moisture content, influencing disinfectant efficacy. [9,24,28] Effective disinfectants like HOCl may be particularly vital in controlling microbial growth in low-moisture environments where pathogens may otherwise proliferate. Therefore, understanding the role of medium composition and moisture in disinfection can aid in optimizing infection control strategies in dental clinics, improving patient safety and reducing the risk of cross-contamination.[29,30]

In conclusion, the findings of this study underscore the importance of both time and medium composition in influencing the efficacy of HOCl as a disinfectant in dental clinics. The time-dependent changes observed across various mediums, particularly in wet and dry conditions, highlight the dynamic relationship between disinfectant effectiveness and environmental factors. Nutrient-rich mediums such as YPD and BHI supported microbial growth, underscoring the need for comprehensive cleaning practices to address organic matter in clinical settings. On the other hand, low-nutrient mediums like DW and PBS consistently supported HOCl's antimicrobial efficacy, suggesting that surface cleanliness plays a pivotal role in ensuring successful disinfection. The interaction of time and medium further emphasizes the necessity for timely and effective disinfection protocols to prevent microbial proliferation over extended periods, ultimately contributing to safer clinical environments.

CONCLUSION

This study demonstrates that vaporized HOCl is an effective disinfectant for reducing microbial contamination, including saliva-based pathogens, in dental clinics. Its effectiveness was influenced by the moisture content of surfaces and the type of medium, with dry conditions generally showing better results in terms of microbial inhibition. The use of HOCl in vaporized form offers an eco-friendly and efficient solution for infection control in dental settings, ensuring comprehensive surface decontamination, especially in hard-to-reach areas. The findings support its integration into infection control protocols, aligning with sustainable healthcare practices, and highlighting its potential for enhancing patient safety and reducing the risk of cross-contamination in dental clinics.

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Re-emergence of Syphilis – An Update for Dental Practitioners

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ABSTRACT

Sexually transmitted infections (STIs) remain a major public health challenge, with over one million curable cases occurring daily among individuals aged 15 to 49. In 2020, an estimated 374 million new cases of syphilis, chlamydia, gonorrhoea, and trichomoniasis were reported. Syphilis has re-emerged, with approximately 8 million adults infected in 2022, including 1.1 million pregnant women, leading to over 390,000 adverse pregnancy outcomes.[1] South Africa, the global epicentre of the HIV epidemic, also has the highest STI burden in the region, according to UNAIDS[2], with KwaZulu-Natal reporting the world's highest HIV and STI rates, highlighting a severe public health crisis. In Gauteng province, 1,255 out of 66,377 pregnant women tested positive for syphilis in 2023, highlighting ongoing challenges despite prevention efforts.[4]

STIs present with oral manifestations, making dental practitioners ideal for early detection and intervention.[5] Syphilis, herpes simplex virus (HSV), human papillomavirus (HPV), and gonorrhoea can cause oral lesions that vary in appearance and clinical behaviour.[6] Identifying these signs is critical not only for infection management but also for detecting possible abuse cases.[7] Given the resurgence of STIs in South Africa, this update highlights their prevalence, transmission, and oral manifestations, emphasizing the role of dental professionals in diagnosis and patient care.

Keywords

Sexually Transmitted Infections, Syphilis, Oral Manifestations, Transmission, Implications,

ORAL MANIFESTATIONS OF COMMON STIs

Syphilis

Syphilis is an infectious disease caused by the tightly-coiled, anaerobic, filamentous bacterial spirochete *Treponema pallidum*.[8-10] It has been called the 'great imitator'[11], on account of the fact that its signs, symptoms, and histopathological characteristics resemble many other diseases. Oral manifestations are found in all stages of syphilis and are often the first signs of infection. Despite the fact that it is curable with antibiotics, it often goes undiagnosed and in about a third of patients, progresses to the tertiary stage that can result in potentially fatal neurologic and cardiovascular diseases.[9] The primary and secondary stages of the disease are highly contagious, therefore early diagnosis is critical.[12] In some case, patients who are undiagnosed may present *only* with oral lesions, making early recognition of the oral manifestations and confirmation for a definitive diagnosis with a biopsy necessary.[13]

The clinical characteristics depend on the stage of the disease. The defining feature of primary syphilis is the chancre, a firm, often painless ulceration that can be solitary or, less commonly, multiple.[14] Primary syphilis manifests typically within 3 to 90 days after exposure[8], most often as a solitary, painless chancre at the site of inoculation.[9] These lesions are highly infectious and typically appear at the site of infection, most often on the genital mucosa, though up to 75% of extra-genital chancres occur in the mouth. Oral chancres, which are found on the lips, tongue, palate, or gingiva, appear in about 4–12% of primary syphilis cases.[14] Lymphadenopathy may also accompany the chancre. Due to the fact that chancres generally resolve spontaneously within 3 to 8 weeks[8], it often results in underdiagnosis due to their asymptomatic nature.[5]

Multiple lesions and systemic symptoms like rashes, fever, and lymphadenopathy mark the secondary stage and appears about 2 to 12 weeks after the primary stage.[8,9,15] Oral manifestations include mucous patches, snail-track ulcers, and condylomalata, which may present as white or pink plaques in the mouth.[15]

Mucous patches are a common manifestation of secondary syphilis, occurring in about 30% of cases. They present as white or pink changes in the mucous membrane, often with a serpentine or "snail-track" pattern.[8-9] Mucous patches can affect various parts of the oral cavity, including the lips, tongue, buccal mucosa, and palate. These patches may undergo superficial necrosis of the epithelium, exposing the underlying connective tissue, leading to raw and denuded areas.[16]

While mucous patches are typically painless, they may be mistaken for other oral lesions due to their variable appearance. In some cases, they resemble leukoplakias, a condition marked by white patches on the mucous membranes, making diagnosis more challenging.[17] They can also occur at the corners of the mouth, where they are known as split papules.[16] Because mucous patches are highly infectious, proper diagnosis and treatment are crucial to

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prevent the spread of syphilis. They typically resolve without treatment, but managing the underlying syphilis infection is essential to prevent disease progression.[17]

Condyloma lata are a manifestation of secondary syphilis, characterized by raised, gray or white, wart-like papillary lesions. These lesions are highly infectious and typically develop in warm, moist areas of the body, such as the groin, underarm, and oral regions. Although condyloma lata are more commonly seen in genital or anal regions, they can also present in the oral cavity, further complicating diagnosis.[14]

Tertiary syphilis may develop years after the initial infection, and affects about 30% of untreated patients and can lead to serious systemic complications, including neurosyphilis and gummas. It can give rise to both unilateral and bilateral trigeminal neuropathy and facial nerve palsy.[18] Potentially, syphilitic osteomyelitis may give rise to trigeminal neuropathy. Tertiary syphilitic lesions occur mostly (70%) on the skin, another 10% occur in the mucosa and the rest in the liver, bones, lung and brain.

Oral lesions of the gumma mainly occur as ulcerated, nodular lesions on the hard palate and tongue[19], although very rarely they may occur on the soft palate, lower alveolus, and parotid gland.[20] On the palate, it starts as one or more painless nodules that ulcerates leading to bony destruction causing palatal perforation and oronasal fistula formation. Gumma can involve the dorsa of tongue causing chronic glossitis. Tongue atrophy can be in two forms – a diffuse atrophy ("luetic glossitis") or with a lobulated and irregular pattern ("interstitial glossitis").[16]

Syphilitic leukoplakia is a rare finding that appears as a homogenous white patch affecting large areas of the dorsum of the tongue. Studies have reported an association between tertiary syphilis and oral squamous cell carcinoma (SCC), particularly of the tongue.[19, 21-23] It is therefore recommended that serology of syphilis should be done in all patients with SCC of the oral cavity.[19]

The worldwide incidence of congenital syphilis increased by 500% between 2011 and 2020.[24] Congenital syphilis is transmitted from mother to child. Oro-facial manifestations can be split into early and later phases: early manifestations may include diffuse maculopapular rash, periostitis (frontal bossing of Parrot), and rhinitis. Late features usually seen at least 24 months after birth, comprise the Hutchinsonian triad of interstitial keratitis of the cornea, sensorineural hearing loss, dental anomalies, along with other deformities like saddle nose and high-arched palate.[25] Dental anomalies of congenital syphilis only arise in teeth in which calcification takes place in the first year of life (typically permanent incisors and first molars). The maxillary incisors are more commonly affected than the mandibular incisors. The incisors ('Hutchinson's incisors') have a peg shape, with a convergence of the lateral margins towards the incisal edge. In some cases, there may be notching of the incisal edge, while in others, there may be a depression on the labial surface. The first molar may be bud-shaped, with multiple rudimentary cusps ('Mulberry molars') and reduced to the size of the adjacent second molar. The normal mesiodistal convexity of the crown may be reduced and enamel hypoplasia may occur.

Despite global antenatal screening efforts, congenital syphilis remains a significant public health issue due to its severe impact on infants, including high mortality rates.[26] Additionally, syphilis increases susceptibility to HIV, amplifying the complexities of managing these co-infections and their impact on perinatal outcomes.[27]

Differential Diagnosis of Oral Syphilis Lesions

The differential diagnosis of the oral lesions of syphilis is challenging because they can be nonspecific and mimic a variety of other diseases.[12,28] In general, the differential diagnosis consists of lesions which present as ulcerations with a firm border or multifocal ulcerations with pseudomembranes. They usually include traumatic granulomas/ulcerations, atypical/major aphthous ulcerations, geographic tongue, deep fungal infections (e.g. histoplasmosis, blastomycosis), tuberculosis, squamous cell carcinoma, Crohn's disease, pyostomatitis vegetans, subepithelial vesiculoerosive diseases (e.g. erosive lichen planus), drug-related ulcerations, or granulomatosis with polyangiitis. Condyloma lata may be confused clinically with human papilloma virus-related papillomas/condyloma accuminata. "Leukoplakia-like" lesions have been reported, and rare cases have even been reported where the oral lesions clinically mimic other uncommon pathologies such as oral hairy leukoplakia and pemphigus vulgaris.[29-31]

As can be seen, there is significant diversity of the clinical and histopathologic manifestations of oral syphilis, therefore practitioners must demonstrate a high degree of suspicion in order to diagnose syphilis.

Herpes Simplex Virus (HSV): HSV infections often present as painful vesicles or ulcers on the lips, tongue, and oral mucosa. These lesions can be recurrent and are highly contagious. In children, recurrent oral herpes lesions, particularly in atypical patterns, can be a sign of possible sexual transmission.[7]

Human herpesviruses (HHVs), including herpes simplex virus (HSV), varicella-zoster virus (VZV), Epstein-Barr virus (EBV), and cytomegalovirus (CMV), play a significant role in the development of various oral diseases. Ballyram et al. (2016)[32] reported that these viruses cause a range of oral manifestations, from common conditions like herpes labialis (cold sores) to more severe presentations such as oral hairy leukoplakia, particularly in immunocompromised patients. HSV infections are notable for causing primary herpetic gingivostomatitis, which mainly affects children, and recurrent cold sores in adults. Reactivation of VZV can result in oral lesions, often seen in patients with shingles, while EBV is associated with oral hairy leukoplakia, a hallmark of immunosuppression, especially in HIV patients. Dental professionals must remain vigilant for these conditions during routine examinations.

Diagnosis of HHV-related oral diseases primarily relies on clinical presentation, though confirmatory tests, such as polymerase chain reaction (PCR) and serological testing, may be required in complex cases. Management typically involves the use of antiviral agents like acyclovir or valacyclovir to reduce the severity and duration of outbreaks. For patients with compromised immune systems, where Herpesvirus infections can pose serious health risks, early intervention and aggressive antiviral therapy are crucial. The

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role of the dentist in recognizing and managing these viral infections is integral, as early detection and comprehensive management can prevent complications, improve patient outcomes, and mitigate the spread of infection.[32]

Human Papillomavirus (HPV): Human papillomavirus (HPV) infections can have significant oral manifestations, particularly in the context of both benign and malignant lesions. The virus is known to infect the epithelial tissues, with the most common oral lesions being squamous cell papillomas, verruca vulgaris, condylomas, and focal epithelial hyperplasia (Heck's disease).

These lesions are often small, exophytic, and may appear as white, pink, or flesh-coloured growths in the oral cavity, primarily affecting the soft palate, tongue, and lips. While most HPV-associated lesions are benign, certain high-risk strains, particularly HPV-16 and HPV-18, are associated with malignant transformations, leading to oropharyngeal squamous cell carcinoma (OPSCC). Ongoing research indicates a rising prevalence of HPV-related OPSCC, particularly among younger, non-smoking individuals.[33] The transmission of oral HPV can occur through direct contact, such as oral-genital or oral-oral transmission. Many HPV infections remain asymptomatic, with the immune system clearing the virus within a few months to years. However, persistent infections with high-risk HPV types can lead to the development of malignancies. Early detection and diagnosis of HPV-related oral lesions are critical in preventing progression to cancer, and dentists play a key role in identifying suspicious lesions during routine examinations. Vaccination against HPV has shown promise in reducing the incidence of oral HPV infections and related cancers, emphasizing the importance of public health measures to curb the spread of the virus.[33]

Gonorrhoea: is caused by *Neisseria gonorrhoeae*, and is the second most frequently reported STI in the United States, after chlamydia. An estimated 600,000 people are infected annually, though only half of these cases are officially reported. A significant concern in treatment is antimicrobial resistance, with about 16% of isolates in 2003 resistant to penicillin and/or tetracycline, and increasing numbers of ciprofloxacin-resistant strains since 1998.[34] Oral gonorrhoea, though rare, presents with nonspecific symptoms that can range from mild erythema to severe ulceration. Oral gonorrhoea often manifests as pharyngitis or as erythematous lesions in the oral cavity. While less common, the presence of oral gonorrhoea in children should prompt an investigation for potential abuse, as it is predominantly transmitted through sexual contact.[7]

Despite the low risk of disease transmission to dentists, patients with a history of gonorrhoea should be treated cautiously due to their higher risk for other STIs. Adhering strictly to the CDC's standard infection control precautions in dentistry virtually eliminates the danger of cross-infection.[34]

Clinical Implications of STIs

The variability and often subtle presentation of oral syphilitic lesions make accurate diagnosis challenging, necessitating a high index of suspicion among oral healthcare providers. Clinicians should include syphilis in the differential diagnosis of atypical or persistent oral lesions, particularly when the lesions exhibit unusual characteristics or fail to resolve with standard treatment.

Diagnostic confirmation relies on serological testing, including rapid plasma reagin (RPR) and fluorescent treponemal antibody absorption (FTA-ABS) tests, along with thorough clinical evaluation. Histopathological examination can also aid in the diagnosis by demonstrating spirochetes within the lesions, as shown in several case reports.[35,36]

The recognition of oral syphilis by dental professionals is critical not only for the management of individual patients but also for the broader public health goal of reducing transmission rates. Educating patients about the risks and symptoms of syphilis and promoting safe sexual practices are essential components of comprehensive care.

Clinical relevance for Dental Practitioners

The identification of oral manifestations of sexually transmitted infections (STIs) is crucial in dental practice, encompassing not just general patient care but also specific roles in public health, early disease detection, and safeguarding vulnerable populations. The clinical significance of STIs for dental practitioners include the following:

Early Diagnosis and Management of STIs

Dentists often encounter the first visible signs of systemic infections, including STIs such as syphilis, herpes, gonorrhoea, and HPV, which frequently manifest in the oral cavity. Early identification allows for timely referrals, appropriate treatment, and prevention of further transmission, thereby playing a crucial role in patient health management.[37]

Public Health Implications

Dentists contribute to public health efforts by identifying undiagnosed infections during routine examination, particularly in populations with limited access to healthcare. This early detection can reduce the community spread of infections and facilitate access to appropriate care.[38] Routine oral screenings for STIs serve as a preventive measure, especially for high-risk populations, including sexually active adolescents and adults, immunocompromised individuals, and underserved communities.[39]

Patient Education and Counselling

Dental practitioners have an essential role in educating patients about the prevention, transmission, and oral manifestations of STIs. Providing guidance on safe sexual practices, encouraging regular health screenings, and advising on follow-up care for any detected lesions can empower patients and reduce stigma associated with STIs.[39]

Interdisciplinary Collaboration

Collaboration with other healthcare professionals, including primary care providers, infectious disease specialists, and paediatricians, ensures comprehensive care for patients presenting with oral manifestations of STIs. This teamwork is vital in managing complex cases and achieving better overall health outcomes.[38]

Child Abuse Detection and Prevention

Detecting oral manifestations of STIs in children, such as lesions associated with syphilis, HPV, or herpes, can be indicative of sexual abuse. Dentists must be vigilant in recognizing these signs and understand their implications as potential indicators of abuse.[7] Dental professionals have a legal and ethical duty to report suspected abuse cases to appropriate authorities. Early identification and reporting can be life-saving, offering the child protection from ongoing harm and ensuring access to necessary support and medical care.[7] Sensitivity during the examination and questioning of the child is crucial when abuse is suspected. Dentists should adopt a trauma-informed approach, ensuring the child's comfort and safety while gathering pertinent information for appropriate action.[7]

Role in Immunocompromised and Special Needs Patients

Special considerations are necessary for immunocompromised individuals or patients with special needs, who may be more susceptible to oral manifestations of infections, including STIs. Dentists should maintain a high index of suspicion and provide tailored care that addresses these patients' unique vulnerabilities.[39]

Awareness of Re-emerging of Infectious Diseases

With the resurgence of diseases like syphilis, dental practitioners must stay updated on current diagnostic criteria, treatment protocols, and the oral signs that could indicate these infections. Continuous education on emerging trends is essential for maintaining high standards of patient care.[37]

Recommendations for Practitioners

Strengthen Continuing Education: by engaging in professional development opportunities that focus on the identification and management of oral STIs, including the latest updates on emerging infectious diseases and their oral presentations.[37]

Implement Routine Screening Protocols by incorporating systematic screening for oral signs of STIs, particularly in high-risk populations. Ensure thorough patient histories are taken, with questions addressing potential exposure and symptoms.[38]

Develop Clear Referral and Reporting Protocols by establishing clear guidelines for referral to medical specialists and mandatory reporting of suspected abuse cases. Ensure all team members are aware of legal obligations regarding child protection and infection control.[39]

Foster a Trauma-Informed, Sensitive Approach by using a trauma-informed approach in all patient interactions, particularly when dealing with potential abuse cases. Focus on creating a supportive, non-judgmental environment that prioritizes patient safety and confidentiality.[7]

Enhance Patient Education by educating patients about oral health's role in systemic disease detection, emphasizing the importance of early diagnosis and preventive care. Use dental visits as an opportunity to discuss overall health and wellness, including STI prevention.[39]

Document Findings accurately by maintaining comprehensive and accurate records of all clinical findings, especially when STIs or signs of abuse are suspected. This documentation is essential for legal, medical, and therapeutic purposes.[37]

Advocate for Public Health Awareness by participating in community education initiatives that raise awareness about the significance of oral health in detecting systemic conditions, including STIs. Promote the integration of oral health into broader health discussions and policies.[38]

Concluding Remarks

The role of dental practitioners extends beyond routine oral care, and includes the responsibility of identifying signs of systemic conditions, including STIs, and acting as frontline responders in cases of child abuse. By enhancing their knowledge, refining clinical protocols, and collaborating across disciplines, dentists can make a significant impact on patient and public health, advocating for comprehensive care and protection for all patients, especially the most vulnerable. Oral manifestations of syphilis are diverse and frequently mimic other common oral conditions, complicating clinical recognition and diagnosis. This review emphasizes the need for increased awareness and education among healthcare providers to improve early detection and management of syphilitic lesions in the oral cavity. Prompt and accurate diagnosis is essential for effective treatment and prevention of transmission, highlighting the critical role of oral health professionals in the ongoing efforts to control syphilis.

Conflict of Interest

The authors declare that the manuscript was created without any commercial or financial associations that may give rise to a conflict of interest.

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Clinical Management of a Tooth that Presented with Necrotic Pulp and an Open Apex: A Case Report

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SN Kabini[1], MP Sithole[2]

ABSTRACT

Introduction:

Pulpal injuries that occur during root development usually present challenges to the treating clinicians. Two approaches are usually taken, which are the apexification or the apexogenesis. Successful treatment is dependent upon prompt diagnosis and complete understanding of the biological processes.

Aims and objectives

This case study aims to report on six-week follow-ups on a young patient who presented with a necrotic pulp on a tooth with an open apex

Methods

A 14-year-old female patient presented with a fractured right central incisor tooth. The radiographic examination demonstrated an open apex with internal root resorption. The tooth was filed with ProTaper Next files and irrigated with sodium hypochlorite. Calcium hydroxide was placed in the root canal and the tooth was temporarily restored with glass ionomer material. The patient was seen after six weeks to evaluate the progress of treatment.

Results

There were signs of apex formation and narrowing of the root canal after the placement of calcium hydroxide

Conclusions

Apexification was successfully accomplished in a young patient who presented with necrotic pulp that was treated with calcium hydroxide paste.

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Key words

Apexification, Apexogenesis, Calcium hydroxide, Mineral trioxide aggregate

Author contribution

Dr SN Kabini 60% - Identification and write-up of the case report
Dr M P Sithole 40% - Reviewing and editing of the case report

INTRODUCTION

Human teeth tend to complete the development of root canals and apex closure three years after they have erupted.[1] Pupal injuries that occur during this period usually present challenges to the treating clinicians. Two approaches are usually taken, which are the apexification or the apexogenesis. Apexification is defined as a procedure to induce a calcified barrier in a tooth with an open apex or the continuous development of an apex in teeth with incomplete root development and presenting with necrotic pulp.[2] Apexogenesis is a vital pulp therapy procedure that is done to facilitate continued physiological development and formation of the root apex.[3] Successful treatment is dependent upon prompt diagnosis and complete understanding of the biological processes.

The field of dentistry has long been associated with regenerative medicine by the utilization of calcium hydroxide to stimulate tissue repair after pulp exposure. Various dental materials such as mineral trioxide aggregate (MTA) that stimulate tissue regeneration emerged, and this resulted in improvements in the clinical management of pulpal exposures and pulp vitality.[4] Traumatic injuries are the main cause of pulpal damage in anterior teeth, and they occur mostly in young children where the teeth apices are still developing, and such cases will require apexification.[5] Materials such as calcium hydroxide powder and MTA have been successfully used to stimulate apex formation in traumatized or diseased pulp.[1, 2, 6] Apexification utilizing calcium hydroxide involves repeated stimulations with calcium hydroxide, over a period of 6- 24 months, until apical closure is achieved.[7]

Case report

A 14-year-old female patient presented at the undergraduate Integrated Clinical Dentistry (ICD) clinic with a fractured right central incisor tooth. A consent for treatment was obtained from the guardian who accompanied the patient to our hospital. The patient was referred to by the emergency department where an emergency root canal treatment was performed on the affected tooth. Thorough medical and dental history were taken and there was no medical contraindication that might affect the success of treatment. The radiographic examination demonstrated an open apex with internal root resorption (Figure 1). The emergency root canal was performed on the affected tooth and the patient was referred to the undergraduate ICD clinic for further management (Figure 2). The tooth was filed and shaped with ProTaper Next files (PTN, Dentsply Tulsa Dental Specialties) and irrigated with 20ml of sodium hypochlorite (NaOCL) (Figure 3). Calcium hydroxide paste (UltraCal™ XS) (Figure 4) was placed in the root canal and the tooth was temporarily restored with glass ionomer material (3M ESPE, St Paul, MN, USA) (Figure 5). The patient was seen after six weeks to evaluate the progress of treatment. An intra-oral radiograph taken after six weeks of treatment

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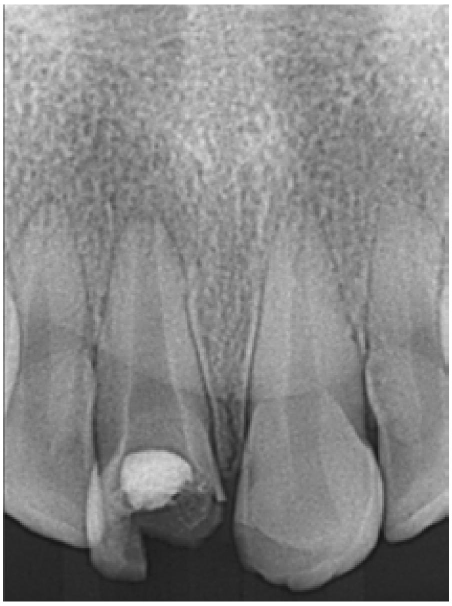
Figure 1: Panoramic radiograph



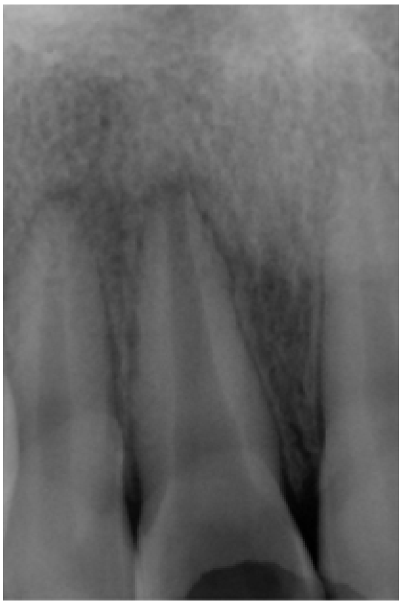


Figure 2: Intra-oral radiograph after emergency treatment. (Far left)
Figure 3: Intra-oral radiograph after filing with ProTaper Next files. (Left)
Figure 4: Calcium Hydroxide (UltraCal™ XS Ultradent). (Above)

Figure 5: Intra-oral radiograph after placement of calcium hydroxide. (Far left)
Figure 6: Intra-oral radiograph after six weeks review. (Left)

demonstrated signs of apical tissue development (Figure 6). The tooth was now ready to be obturated with a gutter-percha.

DISCUSSION

Vital pulp therapy is an appropriate treatment for teeth with open apices and has an important role in preserving pulp vitality in young permanent teeth.[8, 9] The success of this treatment is measured by the formation of calcific barrier in teeth with open apices.[1] Tooth fractures that lead to pulpal exposures usually lead to pulp contamination by oral microorganisms. Calcium hydroxide placed inside the root canals dissociates into calcium and hydroxyl ions. The hydroxyl ions destroy the lipids leading to structural damage of bacterial proteins and nucleic acids. The high alkaline pH of Calcium hydroxide stimulates alkaline phosphatase enzyme which releases inorganic phosphate ions. The inorganic phosphate ions produced reacts with calcium ions in the blood forming calcium phosphate.[10] Calcium phosphate, the molecular unit of hydroxyapatite, produces mineralization of hard tissues leading to the formation of a calcific barrier in a tooth with open apex. The disadvantage of using calcium hydroxide for apexification is that it requires numerous appointments to replace calcium hydroxide.[11]

CONCLUSION

Apexification Is the procedure that is performed to induce a calcified barrier on teeth that present with open apices to promote continuous apical development of incomplete roots presenting with necrotic pulp and was successfully managed by utilizing calcium hydroxide. The apical barrier that is formed will aid in successful completion of an endodontic therapy to ensure proper apical seal.

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Online CPD in **6 Easy Steps**

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

What's new for the clinician – summaries of recently published papers (June 2025)

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Edited and Compiled by Prof V Yengopal, Faculty of Dentistry, University of the Western Cape

1. Clinical and radiographic evaluation of melatonin and chitosan loaded nanoparticles in the treatment of periodontal intra-bony defects: A Randomized controlled clinical trial

Periodontitis is a chronic inflammatory disease characterized by destruction of tooth-supporting tissues. Untreated periodontal diseases may result in formation of intra-bony defects and eventual tooth loss. Adjunctive antimicrobial agents are crucial for patients with persistent periodontal deterioration despite regular mechanical treatments. The delivery method and dosage form have a beneficial effect on the therapy's overall clinical result.[1]

Local drug delivery (LDD) in periodontal diseases aims to enhance the therapeutic profile of the drug and reduce side effects. The therapeutic goal of LDDs is met by directly injecting antimicrobial agents into the periodontal pocket and subgingival sites. This results in active release of the medication in a controlled, sustained manner to fight the microbial attack while minimizing the unfavourable effects.[1] LDDs can be administered as irrigating systems, fibers, gels, strips, films, microparticles, and nanoparticles.[1]

Melatonin is a hormone secreted by the pineal gland, retina, bone marrow, and immune system and as shown to exhibit anti-inflammatory properties and enhance bone formation. It has been demonstrated that melatonin promotes bone repair around titanium dental implants and has shown potential in repairing bony defects. Applying topical melatonin to the ostectomy site after implant placement has been demonstrated to enhance bone mass, density, and bone-to-implant contact, especially in the early stages of healing[1].

Chitosan, a biopolymer derived from chitin (commonly found in the shells of crustaceans), has also emerged as a promising material in periodontics due to its unique biological and physicochemical properties. **Key Properties of Chitosan Relevant to Periodontics include antibacterial, anti-inflammatory and antifungal effects; wound healing and regeneration; Biocompatibility and Biodegradability. Its application for in periodontal therapy include use in:-**

- Local Drug Delivery: Chitosan-based systems (microspheres, nanofilms, and hydrogels) are used for targeted, sustained release of antibiotics and anti-inflammatory drugs directly into periodontal pockets, enhancing treatment efficacy and minimizing systemic side effects
- Scaffolds for Tissue Engineering: Chitosan serves as a scaffold material for guided tissue regeneration, supporting the growth and differentiation of osteoblasts and mesenchymal stem cells, which are essential for bone and periodontal ligament repair
- Oral Hygiene Products: Chitosan is incorporated into mouthwashes, varnishes, and nanogels for its anti-plaque and antimicrobial properties, helping to control biofilm formation and maintain periodontal health.
- Barrier Membranes: Chitosan films and membranes are used in periodontal surgeries to guide tissue regeneration and prevent epithelial downgrowth, improving clinical outcomes

In recent years, the use of loaded nanoparticles (LNPs) has gained attention from clinicians and researchers in periodontal regenerative surgery due to its effective drug delivery to targeted sites of infection and ability to enhance tissue regeneration. In periodontal therapy, traditional local drug delivery (LDD) systems usually face some challenges including rapid breakdown in oral environment which reduce the amount of drug available at target site, resulting in less effectiveness, low solubility, limited in vivo stability, inefficient absorption, and difficulties in achieving prolonged and targeted delivery to site of action. In addition, LDD doesn't reach effective concentration in the periodontal pocket. Consequently, researchers have introduced nanosized drug delivery systems like (LNPs) which protect the drug from breakdown rapidly and enhancing stability and deep penetration into pockets. Additionally, LNP enable controlled, sustained release of the drugs in periodontal treatments with polymeric nanoparticles through enhancing the ability of penetration of the junctional epithelium and slow release of the drug and over a long time. Recent advances in nanotechnology have introduced new types of nanoparticles such as liposomes, metallic nanoparticles and polymeric meicelles.[1]

Al-Agooz et al (2025)[1] from Egypt reported on a randomized controlled clinical trial that sought to evaluate the clinical and radiographic outcomes of utilizing melatonin loaded nanoparticles (LNP)-based delivery system for the treatment of periodontal intra-bony defects.

Methodology

The current study was designed as a triple-blind randomized controlled clinical trial including eligible participants with at least one intrabony defect that was diagnosed clinically and radiographically. The researchers included healthy participants with at least one maxillary or mandibular intrabony defect which had three walled or combined defects without involving the furcation and were between the ages of 25 and 55 years old. The study included both single-rooted and multi-rooted teeth with intrabony defects. Participants were excluded if they had a history of known systemic diseases that affect the periodontal treatment, allergies, or use of chemotherapeutic agents; received antibiotics or periodontal therapy within the previous three months preceding our study; patients with furcation involvement, smokers or tobacco chewers; taking systemic drugs that affect metabolic bone diseases, had poor oral hygiene; or if they were pregnant females.

Before starting the study, the participants were randomly allocated into either one of the three groups by a co-investigator who was blinded to the study procedures and assessment of the study's outcomes. To ensure blinding, the topical gels were prepacked and labelled with unique codes by a separate investigator while the codes were not disclosed to the participants, the principal investigator who conducted the clinical procedures, nor the statistician analysing the de-identified data.

The study groups were categorized as follows: Group 1 (Melatonin LNP group) which included 23 Patients treated with melatonin LNPs gel as an adjunct to scaling and root planing(SRP); group 2 (placebo group) included 24 patients who were treated with placebo gel as an adjunct to SRP; group 3 (chitosan LNPs) which included 20 patients treated with chitosan LNPs gel as an adjunct to SRP.

The primary outcomes included the radiographic measurements of the bone defects to evaluate the bone fill and bone volume using cone beam computed tomography (CBCT). They were measured at the baseline as well as after 6 months from the start of the study.

The radiographic measurements included bone defect height, alveolar crest level, bone defect depth, and the buccolingual (BL) and mesiodistal (MD) width of bone defects. Imaging was performed using the SCANORA® 3D CBCT system.

Measurement of the bone defect height was made from the CEJ to the base of the defect (BD). The depth of the bone defect was measured from the BD to the alveolar crest (AC). The level of the alveolar crest was measured from cementoenamel junction (CEJ) to AC. The defect's BL width in the axial plane was measured as the horizontal distance between the buccal and lingual alveolar crest's most coronal points. The AC point was measured as the junction point of a line drawn perpendicularly from the AC to the root surface. The depth of the intraosseous defect was defined as the distance between AC point and the base of the defect (AC-BD). The MD width of the intraosseous defect was defined as the distance between the AC point and the AC.

The secondary outcomes included clinical parameters such as CAL, periodontal probing depth (PPD), plaque index (PI), and gingival index (GI). The PPD was measured from the free gingival margin to the pocket base while CAL was measured from CEJ to the base of the pocket with a UNC #15 periodontal probe. The GI comprised examination of all teeth surfaces, including the buccal, mesial, lingual, and distal surfaces. The score ranges from 0 to 3. The GI of an individual was obtained by summing the values determined for each tooth and calculating the averages. The PI determines the thickness of plaque along the gingival margin using a periodontal probe. Air was employed to dry the teeth for plaque visualization, which was not pigmented or stained.

Before the start of the study, the participants were motivated by discussing the benefits of plaque control measures and the necessity of periodontal treatment. Detailed periodontal examinations and full mouth periodontal charts were obtained for the eligible participants of this study. CBCT radiographs were obtained at the predetermined sites of CAL.

Following a proper examination and diagnosis, all patients underwent a comprehensive SRP. Ultrasonic tips and Gracey curettes were used to meticulously eliminate calculus, subgingival, and supragingival plaque and the participants were instructed to apply the oral hygiene measures.

After the completion of SRP, the local drug was delivered by a single operator to all patients. The melatonin LNPs gel was injected in the periodontal pocket of patients of the first group, placebo gel was injected in the second group and chitosan LNPs gel was used for the third group using a syringe equipped with Endo-Eze® irrigation tips. The injection was performed until the pocket was filled. For each group, the gel was applied once a week for 4 weeks.

The gel was applied carefully without traumatizing the periodontal tissues. A periodontal pack was used to secure the area for two days following the installation of the LDD system. For one week, the participants were instructed to avoid brushing the area of gel application, using interdental aids, or chewing sticky or hard foods. Patients were instructed for periodic recall monthly for reassurance of oral hygiene measurements then they were recalled at 3 months and 6 months postoperatively.

The clinical and radiographic outcomes were evaluated at baseline and follow-up intervals. The outcomes were evaluated by two independent blind investigators and the inter-examiner calibration was evaluated. In case of disagreement between the primary investigators, a third blind investigator was consulted to solve the disagreement between them.

RESULTS

After screening the potentially eligible patients (70 patients), 3 of them were excluded. Thus, the trial included 67 patients with intrabony defects, 8 males and 59 females. The following clinical indices were evaluated for each patient: PI, GI, PPD, and CAL at baseline, 3 months, and 6 months, whereas radiographic parameters were evaluated at baseline and 6 months. The radiographic parameters included the height, depth, AC level, BL width, and MD width of the intrabony defects. No adverse reactions were reported during the study or side effects were observed during or after treatment with LNPs, and the gel was well tolerated by patients. There were non-statistically significant differences in age and gender among the studied groups.

Evaluation of the PI among the three studies groups showed that PI significantly differed between groups: melatonin LNPs & placebo and melatonin LNPs & chitosan LNPs. However, there were no significant differences between groups placebo & chitosan LNPs at all the study's evaluation times. In contrast, the assessment GI among the three study groups revealed insignificant differences at all points of time($P > 0.05$). Significant differences in PPD were detected between groups melatonin LNPs &placebo ($p < 0.001$) and melatonin LNPs & chitosan LNPs ($p = 0.005$) at baseline while After 3 months, the difference persisted between Melatonin LNPs and Placebo ($p < 0.001$) and between Melatonin LNPs and Chitosan LNPs ($p = 0.027$).In addition, no differences in PPD were noticed between the groups placebo & chitosan LNPs across all measured time points, baseline, 3 months, and 6 months. Evaluation of CAL revealed significant differences between the 3 studies groups at baseline, 3 months, and 6 months.

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The reduction in PPD and CAL after 6 months showed substantial variation among the three groups studied. Melatonin LNPs group exhibited the greatest reduction followed by chitosan LNPs group, while placebo group showing the least reduction. These differences were statistically significant (*p<0.05*), with all pairwise comparisons showing strong significance for CAL and PPD reductions. Over the study periods, all the study groups demonstrated significant improvements in all the clinical outcomes with significant differences between baseline & 3 months, baseline & 6 months, and 3 months & 6 months (p <0.001).

Evaluation of the height of intrabony defect showed that there were significant changes in the reduction of the height after 6 months between all the study groups while melatonin LNPs group demonstrated the highest significant reduction after 6 months (2.10 ±0.34, P< 0.001) with a smaller but significant change in chitosan LNPs group (0.56 ±0.09, P< 0.001). However, the Placebo group showed minimal insignificant change in the height of the intrabony defect (0.05 ±0.19, p= 0.153).

Regarding the defect depth at 6 months, statistically significant differences between melatonin LNPs and placebo group as well as melatonin LNPs and chitosan LNPs group were observed. However, there was no statistically significant difference between placebo and chitosan LNP group. In addition, the melatonin group demonstrated the highest significant reduction in defect depth after 6 months (P <0.001). However, Placebo and Chitosan LNPs groups showed insignificant changes in the depth of the intrabony defect (P >0.05).

The change in the level of Alveolar crest (AC) was evaluated at baseline and after 6 months. There was a significant change in the level of AC in the melatonin LNPs group at 6 months, with slight changes in the placebo and chitosan LNPs groups. The most pronounced change from baseline was in melatonin LNPs group (P <0.001) with insignificant changes in placebo and chitosan LNPs group (P >0.05).

Evaluation of the BL and MD width of intrabony defect showed that there were significant changes in both measurements after 6 months between the three groups (P <0.001). Melatonin LNPs demonstrated the highest significant reduction after 6 months (P<0.001), with a smaller but significant change in chitosan LNPs group. However, the Placebo group showed minimal insignificant changes in the BL and MD width of intrabony defect.

CONCLUSION

This trial showed that melatonin and chitosan LNPs can act as novel and effective adjunctive local drug therapies in the management of periodontal intrabony defects. Significant improvements in the clinical and radiographic outcomes when melatonin and chitosan LNPs were combined with non-surgical periodontal therapy.

Implications for practice

This trial showed that, in addition to its immunomodulatory, anti-inflammatory, and antioxidant properties, melatonin could enhance bone formation and so could potentially eliminate the need for surgical interventions in the management of periodontal diseases.

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2. Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator: a randomized controlled trial

In the extraction of mandibular third molars, local anaesthesia is often the first choice of dentists, including nerve block anaesthesia and local infiltration anaesthesia, of which inferior alveolar nerve block anaesthesia is the most commonly used. At present, there are three mainstream anaesthesia methods for extracting mandibular third molars, namely Halstead technique (HT), Gown-Gates technique (GGT) and Vazirani-Akinosi technique (VAT) (See Table 1)

He & Zhang (2024)[1] designed an indicator to perform combined anaesthesia of the inferior alveolar nerve, lingual nerve, and buccal nerve under the guidance of a 3D printed indicator (IGT). This RCT sought to compare the anaesthesia effects, onset time, and safety of IGT and the Halstead Technique (HT) in the extraction of mandibular third molars.

Materials and methods

A Total of 210 adults who required a mandibular third molar extraction were enrolled in this trial. For inclusion, participants had to:- (1) be between 18–50 years old (2) h have no history of anaesthesia or drug-related allergies. (3) be not taking painkillers, alcohol, or other drugs or foods that may affect the experimental results before surgery. (4) have no contraindications for tooth extraction. (5) have no experience of extracting mandibular impacted third molars. (6) be cooperative. Participants were excluded if they were suffering from systemic diseases or had clinical signs of infection or inflammation.

The 210 patients were divided into two groups, with 105 patients in the IGT group and 105 patients in the HT group. The specific method was as follows: Patients were sorted and assigned visit numbers based on their order of arrival. Those with odd-numbered visit numbers were categorized into the IGT group, whereas those with even-numbered visit numbers were categorized into the HT group. The patient did not know which group they were assigned to. Among them, there were 47 males and 58 females in IGT group, aged 18-49, with an average of 27.90 ±7.50; 56 cases with a tooth extraction position of 38; 49 cases with a tooth extraction position of 48.

Based on the Pell & Gregory classification system (AI =4, AII =49, AIII =18, BI =1, BII =10, BIII =17, CIII =6). HT group, consisted of 45 males and 60 females, aged 18–50, with an average of 29.09 ±7.42; 54 cases with a tooth extraction position of 38; 51 cases with a tooth extraction position of 48. Based on the Pell & Gregory classification system (AI =4, AII =56, AIII =22, BI =1, BII =6, BIII =14, CIII =2). There was no statistically significant difference in general data between the two groups of patients (*P*> 0.05).

Table 1: Technique Descriptors

Halstead Technique (HT)	Gow-Gates Technique (GGT)	Vazirani-Akinosi Technique (VAT)
Also known as the conventional inferior alveolar nerve block. The needle is inserted from the contralateral lower premolar area, targeting the mandibular foramen by contacting bone on the medial surface of the ramus Considered the easiest and most widely practiced technique due to clear anatomical landmarks	The needle is inserted with the patient's mouth wide open, aiming toward the neck of the condyle, just below the insertion of the lateral pterygoid muscle Targets the mandibular nerve trunk before it branches, providing a broader area of anaesthesia Considered more technically demanding, with a higher learning curve	A closed-mouth technique, useful for patients with limited mouth opening (e.g., trismus) The needle is inserted parallel to the maxillary occlusal plane, medial to the ramus, without contacting bone

Comparative Efficacy and Clinical Considerations			
Feature/Outcome	**Halstead Technique (HT)**	**Gow-Gates Technique (GGT)**	**Vazirani-Akinosi Technique (VAT)**
Onset of Anaesthesia	Fastest (approx. 3.5 min)	Slowest (approx. 5.1 min)	Intermediate (approx. 3.1 min)
Success Rate	High, but up to 50% failure in some studies	High (up to 99% in some reports)	High (95.7% success in studies)
Ease of Administration	Easiest, clear landmarks	Most difficult, requires precise technique	Easier in trismus, but fewer landmarks
Pain Perception	Low	Moderate	Low
Complications	Low trismus (5%)	Higher trismus (20%)	Minimal complications, good for limited opening
Supplementary Anaesthesia	Rarely needed	Occasionally needed	Occasionally needed
Indications	Routine cases	Wide field anaesthesia needed	Trismus or limited mouth opening

Comparative Efficacy and Clinical Considerations			
Feature/Outcome	**Halstead Technique (HT)**	**Gow-Gates Technique (GCT)**	**Vazirani-Akinosi Technique (VAT)**
Supplementary Anaesthesia	Rarely needed	Occasionally needed	Occasionally needed
Indications	Routine cases	Wide field anaesthesia needed	Trismus or limited mouth opening

Patients in IGT group received a combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (See Fig 1).

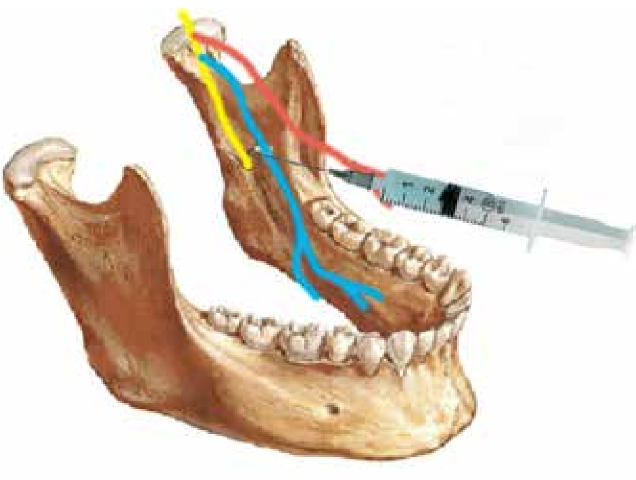

Fig 1: Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator

HT group: Patients in HT group were received Halstead inferior alveolar nerve and lingual nerve block and buccal local infiltration anaesthesia [9] (Fig. 2).

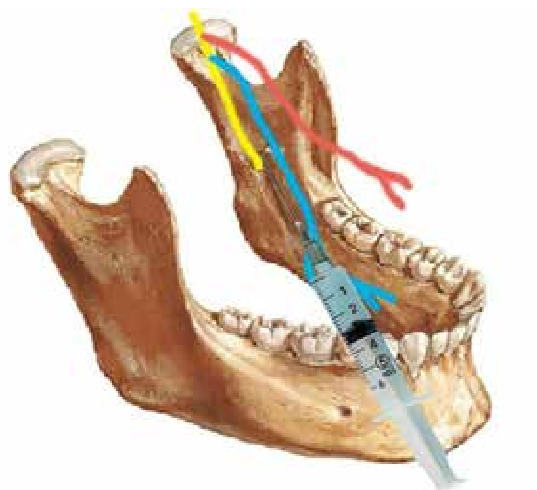

Fig 2: Halstead inferior alveolar nerve block

Anaesthetic injection and tooth extraction were performed by an experienced attending physician. The physician was proficient in the two anaesthesia injection techniques and had rich experience in tooth extraction.. After the surgery, symptomatic treatment with painkillers was given.

Evaluation indicators included:-

Anaesthesia onset time

The nurse recorded the time from the end of anaesthesia injection to the patient's indication of numbness in the lower lip, tongue, and cheeks on the surgical side as the onset time of anaesthesia. If the patient still did not experience numbness in the relevant area 10 min after the injection operation, it was considered as anaesthesia failure, and the effect was recorded as level D. In this case, it was necessary to supplement anaesthesia and complete the tooth extraction operation.

Anaesthesia effect evaluation

According to the patient's intraoperative pain perception, the level of anaesthesia effect was recorded: Level A: satisfactory anaesthesia effect, and the patient has no pain in the operating area during surgery; Level B: The anaesthesia effect is good, and the patient has tolerable pain in the operating area during surgery; Level C: The anaesthesia effect is average, and the patient has pain in the operating area during surgery and needs to supplement local infiltration anaesthesia; Level D: Anaesthesia failure.

Safety evaluation

Recorded the number of times positive aspiration, hematomas, nerve injuries (sensory abnormalities, temporary facial paralysis), and other complications (syncope, closed jaw, instrument separation, etc.) during the anaesthesia process, and kept a record.

Results

The onset time of anaesthesia in two groups of patients was 173.09 ±53.50 s in IGT group and 182.89 ±56.20 s in HT group, respectively, with no statistical difference *(P=* 0.213). The success rate of anaesthesia in IGT group was 95.2%, and the success rate of anaesthesia in HT group was 90.5%. There was no statistical difference between the two groups (*P*= 0.180). In terms of anaesthesia effect, there was no statistically significant difference between the two groups (*P*= 0.933). Among them, the A/B level ratio of anaesthesia effect in IGT group was 84.8%, and that in HT group was 81.0%. In terms of anaesthesia safety there were 2 cases of anaesthesia risk factors in IGT group, both of which were positive aspiration, and 9 cases of anaesthesia risk factors in HT group, including 7 cases of positive aspiration, 1 case of syncope, and 1 case of hyperventilation and trembling. The incidence rate of anaesthesia risk factors in IGT group was 1.9%, while in HT group, it was 8.6% *(P= 0.030).*

CONCLUSION

The Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (IGT) was found to be similar to the Halstead Technique (HT) in terms of anaesthesia success rate (*P*=0.180), anaesthesia onset time (*P*=0.213), and anaesthesia effect (*P*=0.933). However, IGT was found to be significantly safer than the HT.

Implications for practice

The new method of inferior alveolar nerve block guided by a 3D printed indicator was found to be equivalent in terms of its anaesthetic effect but significantly safer than the HT. Clinicians can consider this has an alternative to the traditional HT to obtain anaesthesia

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CPD questionnaire on page 288

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

Helps fight the root cause of oral issues*

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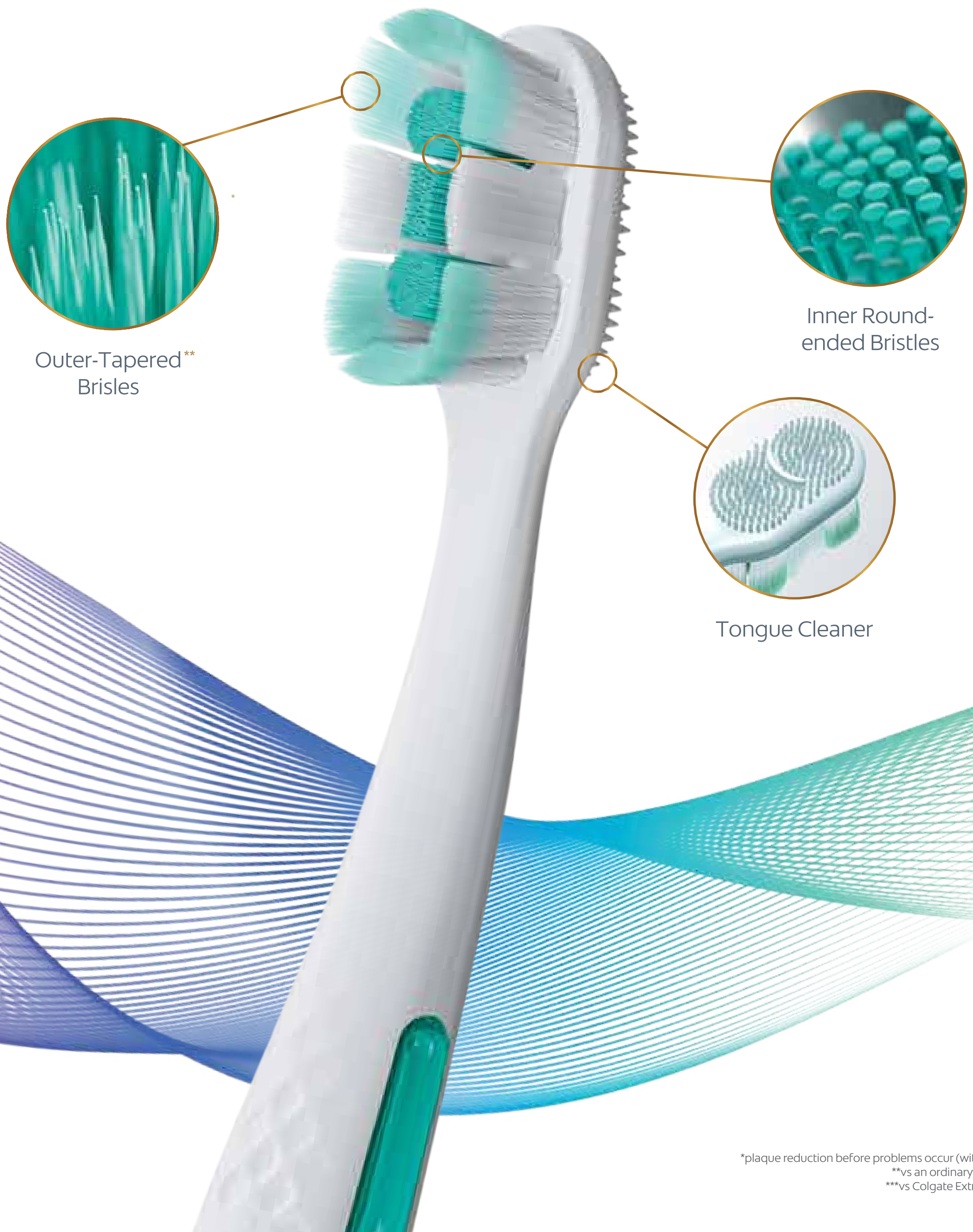

*plaque reduction before problems occur (with 2x daily brushing)
**vs an ordinary flat trim toothbrush
***vs Colgate Extra Clean Toothbrush

Ethical use of dental radiographs

SADJ JUNE 2025, Vol. 80 No.5 P272-P273

P Govan

Radiographic imaging play an indispensable role in modern dentistry, supporting accurate diagnosis and guiding clinical decision-making. Yet, as awareness grows about radiation exposure and the broader implications of diagnostic imaging, dentists must navigate the ethical dimensions of radiograph use with clarity and care, especially within the uniquely complex environment of South African oral healthcare in both the private and public sectors.

Balancing Autonomy and Clinical Judgment

Central to ethical dental care is the principle of patient autonomy, firmly entrenched in the Health Professions Council of South Africa (HPCSA)'s *Ethical Rules of Conduct* and Section 6 of the *National Health Act 61 of 2003*. These frameworks enshrine the patient's right to make informed choices, including decisions about diagnostic imaging. The dentist has to ensure patients understand the reason for recommending radiographs, the potential benefits, and any associated risks.

The key is clear, and easy to understand communication. Patients must feel empowered to ask questions, express concerns, and make decisions aligned with their values. However, autonomy does not entitle a patient to demand care that falls below acceptable clinical standards, nor can a practitioner be compelled to provide treatment that compromises safety or quality.

To establish trust, practitioners must respect patients' autonomy, their right to decide whether or not to undergo any dental treatment, even where a refusal may result in harm to themselves. This right allows patients to make their own informed choices, and to live their lives by their own beliefs, values, and preferences.

Where a patient declines radiographs or fewer radiographs which are deemed essential for diagnosis or treatment, clinicians face an ethical tension: respect the patient's decision while upholding professional standards. In such cases, the conversation should be carefully documented, including the rationale for imaging, the patient's concerns, and the potential impact on outcomes. Dentists may need to adapt treatment plans or refer patients to another practitioner when consensus cannot be reached.

Clinical Justification and the ALARA Principle

The ethical justification for any radiograph must rest on clinical necessity. South Africa's *Hazardous Substances Act* (Regulation R1332) requires radiographic imaging to be used only when its benefits clearly outweigh potential risks. This aligns with the global ALARA principle "*As Low As Reasonably Achievable*" which underscores the responsibility to minimise radiation exposure without compromising care.

Routine or "checklist" imaging should be avoided. Instead, decisions should be based on caries risk, periodontal status, clinical presentation, and patient history. While radiographs are indispensable for visualising interproximal surfaces, bone levels, root integrity, and subgingival pathology, their use must be justified for each individual case.

If a patient refuses radiographs for reasons such as fear of radiation, financial constraints, or personal beliefs, the dentist is still legally and ethically required to meet the standard of care. Where appropriate imaging cannot be obtained, the practitioner may ultimately need to consider withdrawing from care in a responsible, documented manner. This should involve issuing a written explanation to the patient, outlining the risks of non-diagnosis and the legal basis for discontinuation of services.

The dentist may properly decline to treat the patient. Under these circumstances, termination of the dentist-patient relationship presents the least risk to the dentist because failing to take dental radiographs when needed for proper diagnosis qualifies as substandard care. This is so even if the patient signs a form stating refusal of radiographs as a personal preference and understands that the dentist cannot provide proper treatment because the dentist still has a legal and ethical duty to treat within the standard of care.

If termination is the preferred option, elaborate documentation in the patient's record is recommended. A dismissal letter should also be sent by to the patient emphasising failure to treat some dental conditions may result in permanent, irreversible damage to the patient's dental health.

Managing Informed Refusal

When patients decline necessary radiographs, clinicians should consider using an "informed refusal" process. This involves clearly outlining the purpose of the radiographs, the consequences of non-compliance, and recording the refusal in the clinical notes. Where possible, the patient should sign a written acknowledgement confirming that they have understood the dentist's recommendations and are making an informed decision to proceed differently.

This documentation is not a waiver of responsibility, but it does provide a factual record should any future disputes arise. While it does not offer absolute legal protection, it reflects the clinician's efforts to act transparently and in the patient's, best interests, important factors in any legal or regulatory review.

Following these procedures will provide evidence against a later claim that the patient did not know of or understand the recommendation. While this type of record or disclaimer is not absolute protection against litigation, it will ultimately demonstrate to the courts what the recommendations of the dentist were and that the dentist cared enough for the patient to take the time to explain the potential adverse consequences of the patient refusing the treatment, and it will raise in the mind of the judge of the fact that the patient may have contributed, by individual choice, to the negative outcome.

Access, Portability, and Data Protection

Ethical radiographic practice extends beyond image acquisition. Sharing and storing radiographic data must comply with South Africa's Protection of Personal Information Act (POPIA), which mandates that patient data be handled confidentially and securely. Dentists should only share radiographs with proper consent and through encrypted or password-protected channels.

When patients change providers or request prior imaging, dentists should facilitate the transfer promptly, without discrimination based on the patient's ability to pay. This collaborative approach supports continuity of care and avoids unnecessary repeat exposures.

Emergency Care and Ethical Duties

Emergency dental care presents another area where ethics intersect with practicality. In situations involving trauma, swelling, or acute infection, radiographs may be critical to immediate care. However, when patients still refuse imaging, clinicians must do their best to manage the situation using available information—while respecting the patient's right to decline. In such cases, careful documentation of the refusal, clinical presentation, and modified approach to care is essential.

Conclusion

In the South African dental landscape, where patients' expectations, healthcare regulations, and access to care vary widely ethical use of radiographs requires thoughtful, case-by-case judgment. Dentists must weigh the clinical need for imaging against the patient's right to choose, all within the boundaries of professional guidelines and legal obligations.

How austerity measures are dismantling public oral health: sliding from crises to catastrophe

SADJ JUNE 2025, Vol. 80 No.5 P270-

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The Gauteng Department of Health (GDoH) unilaterally implemented austerity measures on 1st April 2025. This drastic fiscal measure by the GDoH, contravened the legally enforceable and mutually obligatory contract with dentists and specialists effective 1 April to 31 March 2026. The department hastily and abruptly suspended commuted overtime; enforced a moratorium on filling of posts; terminated sessional posts including the services of clinicians with scarce skills. By implication, the Gauteng Department of Health (GDoH) suspended certain specialist oral health services and in some cases, discontinued the provision of oral health care in the province and beyond. This regrettable and unjustifiable move by the GDoH has collapsed oral health services in the province and nationally. This crippling assault on the profession has pushed the national oral health service to the brink of collapse, and unable to regain its former glory. We can only wonder if time can restore what fate has torn? Or leave it lost, forgotten and forlorn.

Dentists and dental specialists play a crucial role in providing oral health services across the province and the country. These highly skilled professionals are dedicated to ensuring that quality oral healthcare always remains accessible to the population. However, only 3.6% of registered dental specialists (490) are employed full-time in the public sector, highlighting a serious shortage of expertise. [1-3] Similarly, just 13% of the country's dentists (6,800) serve over 85% of the population in the public healthcare system, reflecting a significant gap in resources. [1-3] This shortage is further exacerbated by the increasing number of private patients seeking care in public facilities due to high out-of-pocket costs and limited dental benefits from medical schemes. [4-5]

Consequently, the three academic hospitals (UP, Wits and SMU) act as the sole and exclusive providers of specialized oral health services in the province. Therefore, any drastic change in the staffing and resourcing of these institutions will have dire consequences for the delivery of these specialized services. The imposed austerity measures have but exacerbated the inability of the Gauteng Province to deliver on its policy mandate to progressively increase access and equity to oral health services. [6] This epitomized by inadequate training of fit for purpose graduates because of the shrinking budget allocations to Dental Schools. Similar financial constraints have thwarted efforts to improve the public oral services infrastructure.[4] The calamitous consequences of the above challenges include the following:

a. Extended waiting periods for minor oral health procedures, leading to a reliance on dental extractions.
b. Excessive delays and backlogs in accessing specialist oral health services.
c. Loss of experienced dentists and specialists due to departures from the academic and public sectors.
d. Declining graduate quality due to limitations in teaching and learning resources.
e. Insufficient research output to guide clinical practice and policy decisions.
f. Gradual deterioration in the overall quality of oral healthcare.

The evidence above points to the imminent collapse of the oral health service in Gauteng and nationally. The austerity measures currently in force have far-reaching negative repercussions on service rendering, teaching and learning and accreditation of dental schools.

1. Disruption of after-hours and Saturday clinics in the Public Oral Health Clinics (POHCs)

The termination of commuted overtime (COT) has resulted in the closure of weekday after-hours clinics and the total shutdown of Saturday clinics in POHCs. These services serve as a lifeline for patients who are unable to access dental care during standard working hours or during weekends. By discontinuing COT, the POHCs are compelled to unwillingly reintroduce and implement the scheduling and appointment system for all patients; set daily limits of patients that can be managed during the normal working hours and discontinue Saturday clinics. The immediate and unprecedented consequences of this new dispensation include:

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This article was not subjected to formal peer review and is intended to contribute constructively to ongoing professional dialogue on the current challenges facing public oral health services and dental education in South Africa.

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a. Worsening oral health inequality, which disproportionately affects the vulnerable and low-income communities.
b. Declining focus on preventative and health promotive services, leading to a more reactive approach to care.
c. Continued increases in waiting times, patient backlogs, and delays in Public Oral Health Clinics.

Currently, more than 2700 patients in Gauteng have not received the necessary dental treatment in the POHCs since the implementation of the austerity measures.

2. Excessive upstream referrals and the congestion of tertiary dental hospitals

The termination of commuted overtime (COT) has severely disrupted patient management in dental schools, drastically reducing available clinical hours and limiting the number of patients seen daily. General dental practitioners (GDPs) in the POHCs have traditionally managed uncomplicated cases, ensuring efficient referrals to specialists only when necessary. This structured system improves the delivery of oral health services by preventing an overwhelming influx of patients into teaching institutions. However, the sustainability of this system hinges on a well-resourced public oral health service with adequate personnel and working hours. Without sufficient support, the referral framework collapses, worsening clinical outcomes rather than improving them. As GDPs are increasingly forced to send even simple cases to the next available centers, dental schools are now bearing an excessive burden. The spike in referrals has clogged the system, creating inefficiencies, longer waiting lists, and extensive backlogs for specialist care. If this trend continues unchecked, the strain on teaching institutions will become insurmountable, threatening the quality, accessibility, and long-term sustainability of public oral healthcare. Urgent intervention is needed to restore balance and prevent irreversible damage.

3. Impact of austerity measures on dental education

The joint appointments (dentists, registrars and specialists) constitute approximately 34% of the dental workforce and periodicals make up 18% of the labour responsible for teaching and learning, service rendering, service learning and research. Dental schools operate between 7 am and 6pm daily to meet the accreditation and training demands, while postgraduate programs continue during the weekends. The termination of COT for dentists and dental specialists, and non-renewal of the sessional appointments, implies a loss of at least 20% of curriculated time. It is impractical and unfeasible for dental schools to implement any dental program, having lost at least 20% of the training time and staff complement. The quality and scale of student clinical supervision (undergraduate and postgraduate) will be severely affected. First, the student supervisor ratio will increase substantially; second the duration of clinical exposure will be reduced significantly. This is tantamount to training a dentist for four years instead of five, and a dental specialist for significantly less time to acquire critical expert skills. The prodigious and undesired consequences of this decision by the GDoH are:

a. Imminent loss of accreditation for all dental programs by the Health Professions Council of South Africa (HPCSA).
b. Failure to produce competent graduates, dentists and dental specialists to meet national healthcare needs.
c. Limited access to affordable, high-quality specialist oral health services, affecting patient care.
d. Declining patient outcomes and diminished oral health-related quality of life across communities.

The austerity measures have far-reaching national consequences, as Gauteng province is responsible for graduating over 75% of the country's oral health workforce. The termination of commuted overtime and the discontinuation of sessional staff appointments reflect an impulsive, unexamined fiscal decision, that lacks consideration for both the immediate and long-term implications of oral health workforce planning.

4. Impact of austerity measures on labour relations and staff morale

The unilateral implementation of austerity measures by the GDoH represents a blatant violation of labour relations, further undermining worker's rights, disrupting workplace harmony, with potential to set a dangerous precedent for unfair employment practices. The morale of staff, emotional and psychological well-being and commitment are presently at all-time low. The removal of COT will inevitably push clinicians toward the private sector, worsening the already fragile manpower crisis in public healthcare and universities. Without a steady foundation of skilled and experienced professionals, both dental schools and essential services may find themselves struggling to comply and function.

CONCLUSION

We are witnessing the detrimental consequences of austerity measures on oral health, jeopardising patient care and the integrity of essential programs. To prevent further disruption, we urge immediate intervention to safeguard accreditation, retain experienced staff, and ensure the long-term sustainability of the oral health service. We therefore implore the GDoH to reverse the termination of COT for dentists and specialists without delay and initiate a collaborative dialogue with all stakeholders to address the underlying concerns.

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CPD questionnaire

Re-emergence of Syphilis - An Update for Dental Practitioners

1. Choose the CORRECT answer. Which province in South Africa has the highest rates of HIV and STIs in the world?

A. Gauteng
B. Eastern Cape
C. KwaZulu Natal
D. Western Cape

2. Which answer is CORRECT. In primary syphilis, what is the characteristic oral manifestation?

A. Mucous patches
B. Chancre
C. Condyloma lata
D. Gumma

Managing Saliva and Surface Contamination in Dental Clinics: A Hypochlorous Acid-Based Approach to Sustainable Infection Control

3. Choose the CORRECT statement. Which Sustainable Development Goals (SDGs) does this study align with?

A. SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth).
B. SDG 3 (Good Health and Well-Being) and SDG 12 (Responsible Consumption and Production).
C. SDG 4 (Quality Education) and SDG 13 (Climate Action).
D. SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities).

4. Select the CORRECT option. What is one of the key findings of the study regarding HOCl's effectiveness?

A. It was less effective in dry conditions compared to wet conditions.
B. Low-nutrient media enhanced HOCl's disinfectant performance.
C. HOCl's efficacy was unaffected by medium composition or exposure time.
D. High-nutrient media showed the best results for microbial inhibition.

5. Which option is CORRECT. How does vaporized HOCl contribute to sustainable infection control in dental clinics?

A. By eliminating the need for pre-cleaning surfaces.
B. By replacing all manual cleaning practices.
C. By reducing reliance on harsh chemicals and single-use plastics.
D. By increasing the use of disposable barriers.

6. Choose the CORRECT answer. Why are bioaerosols generated during dental procedures a significant concern?

A. They increase the clinic's operational costs.
B. They only affect high-touch areas, such as dental chairs.
C. They reduce the effectiveness of standard cleaning protocols.
D. They can settle on surfaces and act as reservoirs for cross-infection.

First permanent molar root canal configurations in a Black South African sample: a descriptive micro-computed tomographic report.

7. Choose the CORRECT option. According to the available literature, which of the following factors were identified to least likely play a role in the diversity of root canal configurations:

A. Sex
B. Populations
C. Geographic location
D. Diet

8. Which answer to this question is CORRECT: Which of the following is the least accurate concept where root canal configurations might play a role in endodontics?

A. Coronal seal
B. Treatment planning
C. Endodontic retreatments
D. Planned apical surgery

9. Select the CORRECT statement. Which of the following is the most accurate description of a looped accessory canal:

A. Circular root canal located on the lateral aspect of the main canal, with a smaller diameter where one end is connected to the main canal
B. Root canal branch located on the lateral aspect of the main canal, with a smaller diameter where one ends blindly
C. Spike or rod-shaped root canal located on the coronal aspect of the main canal, with a relatively smaller diameter compared to the main canal
D. Semi-lunar root canal located on the lateral aspect of the main canal, with a relatively smaller diameter where both ends are connected to the main canal

10. Which option is CORRECT. In the current study, what was the most common root canal configuration in maxillary first molars:

A. 3MXFM MB1 DB1 P1
B. 3MXFM MB1-2-1 DB1-2-1 P1
C. 3MXFM MB1-2 DB1 P1
D. 3MXFM MB1 DB1-2 P1

11. Select the CORRECT statement. Which of the following is the most accurate report of common configurations found in the present study when accessory canals are included in the Ahmed et al. classification system:

A. A total of 90 and 82 unique configurations were respectively found in the maxillary and mandibular teeth
B. A total of 87 and 85 unique configurations were respectively found in the maxillary and mandibular teeth
C. A total of 97 and 85 unique configurations were respectively found in the maxillary and mandibular teeth
D. A total of 74 and 84 unique configurations were respectively found in the maxillary and mandibular teeth

Clinical Management of a Tooth that Presented with Necrotic Pulp and an Open Apex: A Case Report.

12. Choose the CORRECT answer. Tooth apex closure occurs:

A. Two years post-eruption
B. As soon as the tooth erupts
C. One-year post-eruption.
D. Three years post-eruption
E. None of the above

13. Select the CORRECT statement. Apexogenesis

A. It is a non-vital pulp therapy procedure
B. Does not facilitate continued physiological root development
C. It is a vital pulp therapy procedure
D. All the above
E. None of the above

14. **Which of the options is CORRECT. Mineral trioxide aggregate (MTA)**
    A. Does not stimulate tissue regeneration
    B. Does not improve clinical management of pulpal exposures
    C. Cannot be used for vital pulp therapy
    D. Stimulates tissue regeneration
    E. None the above

15. **Choose the CORRECT statement. Calcium hydroxide**
    A. Requires repeated stimulation during the apexification process
    B. Does not require repeated stimulation during apexification process
    C. Does not promote apical closure of a tooth with open apex
    D. All the above
    E. None of the above

16. **Which of the following is CORRECT. Vital pulp therapy**
    A. Does not promote the formation of calcific barrier in teeth with open apices
    B. Promotes the formation of calcific barriers in teeth with open apices
    C. Is appropriate treatment for teeth with open apices
    D. Does not preserve pulp vitality in young permanent teeth
    E. B and C are correct

What's new for the clinician. Evidence-based dentistry.

17. **Select the CORRECT answer. In the Al-Agooz et al trial, triple blinded in the context of this study was as follows choose the correct option**
    A. Patient, operator and assessor were blinded
    B. Co-investigator, operator and assessor were blinded
    C. Patient, assessor and statistician were blinded
    D. Co-investigator, assessor and statistician were blinded

18. **Select the CORRECT option. In the Al-Agooz et al trial, choose the statement with the most correct finding from the trial**
    A. Evaluation of the PI among the three studies groups showed that PI did not differ between groups: melatonin LNPs & placebo and melatonin LNPs & chitosan LNPs.
    B. There were no significant differences between groups placebo & chitosan LNPs at all the study's evaluation times.
    C. The assessment GI among the three study groups revealed significant differences at all points of time($P < 0.05$).
    D. No Significant differences in PPD were detected between groups melatonin LNPs &placebo and melatonin LNPs & chitosan LNPs at baseline.

19. **Which of the following statements is CORRECT. In the Al-Agooz et al trial, regarding the defect depth at 6 months, choose the most correct statement in terms of the trial findings:**
    A. There were statistically significant differences between melatonin LNPs and placebo group as well as melatonin LNPs and chitosan LNPs group.
    B. There was statistically significant difference between placebo and chitosan LNP group.
    C. The melatonin group demonstrated the lowest reduction in defect depth after 6 months
    D. Placebo and Chitosan LNPs groups showed insignificant changes in the depth of the intrabony defect ($P > 0.05$).

20. **Choose the CORRECT answer. In the He & Zhang (2024) trial, which of the following statement reflects the correct trial findings?**
    A. The Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (IGT) was found to be similar to the Halstead Technique (HT) in terms of anaesthesia success rate ($P = 0.180$) anaesthesia onset time ($P = 0.213$), and anaesthesia effect ($P = 0.933$). However, IGT was found to be significantly safer than the HT.
    B. The Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (IGT) was found to be similar to the Halstead Technique (HT) in terms of anaesthesia success rate ($P = 0.180$) only
    C. The Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (IGT) was found to be similar to the Halstead Technique (HT) in terms of anaesthesia success rate ($P = 0.180$) anaesthesia onset time ($P = 0.213$), and anaesthesia effect ($P = 0.933$) and safety ($P = 0.333$)
    D. The Combined block anaesthesia of inferior alveolar nerve, lingual nerve and buccal nerve guided by 3D printed indicator (IGT) was found to be similar to the Halstead Technique (HT) in terms of anaesthesia success rate ($P = 0.180$) and anaesthesia safety ($P = 0.933$)

Ethics: Ethical use of dental radiographs

21. **Choose the CORRECT answer. According to the National Health Act 61 of 2003 and HPCSA ethical rules, patients have the right to:**
    A. Demand any dental treatment they believe is necessary
    B. Refuse all forms of treatment without any consequence
    C. Make informed decisions about their care, including radiographs
    D. Insist on treatment that does not meet clinical standards

22. **Which option is CORRECT. The ALARA principle stands for:**
    A. Always Limit All Radiographic Applications
    B. As Low As Reasonably Achievable
    C. Align Legal And Radiologic Advice
    D. Allowable Limits and Radiographic Access

23. **Select the CORRECT statement. When a patient refuses radiographs that are clinically necessary, the dentist may:**
    A. Proceed with treatment as best as possible
    B. Refuse to continue treatment, with proper documentation
    C. Refer the patient to a government clinic
    D. Waive all responsibility through a verbal agreement

24. **Which of these answers is CORRECT. What is the purpose of an "informed refusal" form?**
    A. To allow the dentist to ignore the standard of care
    B. To avoid having to explain procedures to patients
    C. To document that the patient understands and declines recommended care
    D. To transfer liability to another practitioner

25. Choose the CORRECT statement. According to POPIA, when sharing radiographic data, dentists must:
A. Obtain a court order
*B. Ensure patient consent and secure transfer
C. Send the images only in printed form
D. Charge a fee for data transfer

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