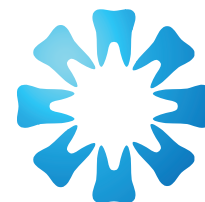


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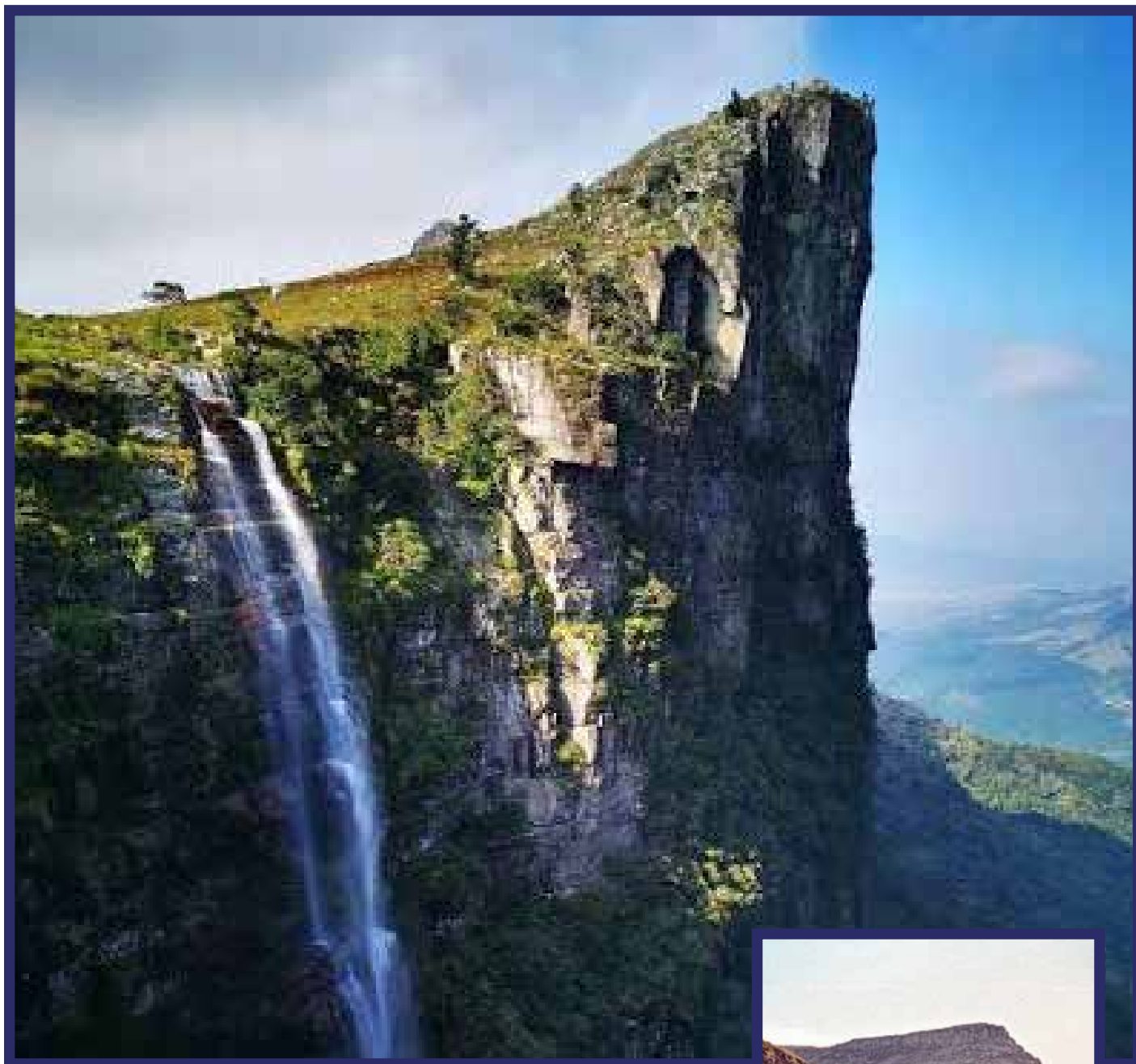
JULY 2026
Volume 81 Number 6

ISSN No. 2519-0105 – Online Edition
ISSN No. 1029-4864 – Print Edition



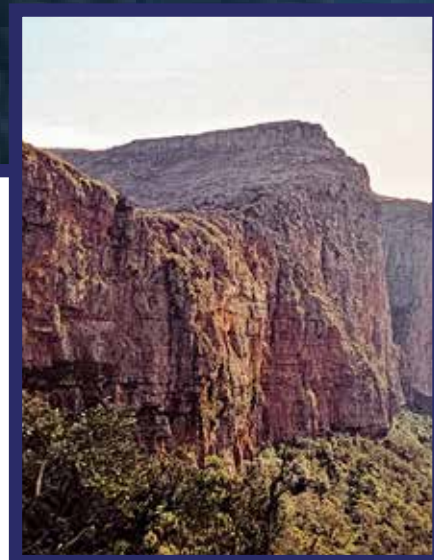
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2505236577 10/25

EDITORIAL OFFICE**Managing Editor:**

Prof NH Wood

Editorial Assistant:

Mr Dumis Ngoye sadj@sada.co.za

Please direct all correspondence to:

South African Dental Association
Private Bag 1, Houghton 2041
Tel: +27 (0)11 484 5288 info@sada.co.za

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SADA CONTACT DETAILS
Website smalls advertising:
 marketing@sada.co.za

CPD Enquiries:
 sadj@sada.co.za

Member contact detail update:
 South African Dental Association
 Tel: +27 (0)11 484 5288
 sadamembership@sada.co.za

PRODUCTION OFFICE
Publisher:
 Creative Space Media
 Tel: +27 (11) 467 3341
 www.creativespacemedia.co.za

Project management:
 Leani Thomson – Leani@creativespacemedia.co.za
 Sizwe Zim – sizwe@creativespacemedia.co.za

General and advertising enquiries:
 James Chademana
 james@creativespacemedia.co.za

Design and layout:
 Leani Thomson
 leani@creativespacemedia.co.za

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The consultation: the most important procedure we perform

SADJ JULY 2026, Vol. 81 No.6 P361-364

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

INTRODUCTION

Every dentist remembers a technically demanding case. The difficult extraction, the fractured instrument discovered halfway through treatment, or the implant placed under less-than-ideal circumstances. Cases like these remain with us because dentistry can be described as a profession defined by intervention. Yet patients often remember something entirely different. Patients remember the clinician who explained a diagnosis in language they could understand. They remember the dentist who recognised their anxiety before treatment began, and specifically feeling reassured, respected, and, perhaps most importantly, heard.

This difference in perspective is both fascinating and revealing. Modern dentistry has become extraordinarily sophisticated in our routine use of digital imaging, computer-assisted workflows, advanced biomaterials, and increasingly precise diagnostic technologies. We measure everything we do. However, one of the most important components of clinical care remains remarkably resistant to measurement: the consultation.

This is perhaps surprising, given the growing emphasis on patient-centred care and shared decision-making within healthcare. These approaches recognise that effective care depends on clinical expertise and on communication, trust, partnership, and an understanding of the patient's individual needs and preferences. And yet, within dentistry, these concepts remain less clearly defined and less systematically evaluated than many of our technical procedures.

Perhaps this is because we continue to think of the consultation as something of a ritual that occurs before treatment: An introduction. A necessary administrative step. A conversation that precedes the real work. But what if we have misunderstood its role entirely and the consultation is not simply the beginning of treatment but in many respects, is the treatment?

1. Dentistry's invisible procedure

Dentistry is a measurable profession.

We measure periodontal pocket depths in millimetres, we record plaque scores and bleeding indices, we quantify bone loss, assess marginal integrity, monitor implant survival, and evaluate restorative longevity. Modern dentistry is rich in numbers, indices, radiographs, scans, and clinical outcomes. And rightly so.

Measurement has transformed the profession. It allows us to compare treatments, evaluate outcomes, improve techniques, and advance scientific knowledge. Evidence-based practice depends upon our ability to observe, quantify, and critically evaluate what we do. Yet there is an interesting paradox at the heart of clinical dentistry. Some of the most important elements of patient care remain

remarkably difficult to measure. I am of course considering the consultation.

There is no universally accepted index for listening. No periodontal probe can assess empathy and no radiograph can quantify reassurance. There is no chairside instrument capable of measuring whether a patient felt heard, understood, respected, or safe, but these are the experiences that profoundly influence the therapeutic relationship.

Our scientific literature increasingly recognises communication and trust as fundamental components of patient-centred dental care. Effective communication has been associated with improved trust, reduced anxiety, greater patient satisfaction, and better adherence to treatment recommendations. At the same time, researchers continue to acknowledge that both communication and trust remain complex and difficult to define within the context of dentistry itself. Perhaps this explains why the consultation occupies such a curious position within the profession. Every clinician performs it. Every patient experiences it. Yet it rarely receives the same attention as the procedures that follow.

We celebrate technical excellence, and appropriately so. Dentistry demands extraordinary precision and remarkable technical skill. But ask patients what they remember years after treatment, and the answers are often at the emotional and communication interface. They remember the dentist who listened and the explanation that transformed fear into understanding. They remember being reassured that treatment was possible and all this the first clue that the consultation deserves greater attention than we have traditionally afforded it. The treatment began with a conversation.

2. What patients actually remember

Dentists remember details.

We remember the challenging extraction that finally yielded after thirty frustrating minutes. We remember the implant placed in a compromised ridge, the difficult endodontic case, the fractured instrument, the perfectly adapted restoration, and the carefully executed periodontal surgery. Our professional memories are often built around procedures.

Patients, however, remember something entirely different. Very few patients can recall the shade of a restoration several years after treatment; fewer still remember the dimensions of an implant, the intricacies of an occlusal adjustment, or the probing depths recorded during a periodontal examination. But many can describe with remarkable clarity a dentist who took time to explain a diagnosis, the clinician who recognised their anxiety, or the reassuring words that transformed a frightening experience into a manageable one. This difference in perspective should not surprise us.

Patients are rarely in a position to evaluate technical excellence directly. They cannot easily assess the marginal adaptation of a crown or the precision of a surgical flap design. What they can assess is how they were treated as individuals. Did the clinician listen? Did they explain? Did they appear rushed? Did they demonstrate patience? Did they inspire confidence?

We consistently identify communication, trust, empathy, and the establishment of a meaningful therapeutic relationship as central components of patient-centred care. In fact, these elements repeatedly emerge as some of the strongest determinants of patient satisfaction and long-term engagement with dental treatment. Therefor this creates an interesting paradox when clinicians devote enormous energy almost exclusively into refining technical skills. Dentistry demands exceptional precision of course. Yet the aspects of care that patients remember most vividly are often those that occur before treatment begins.

3. Listening in a profession built around doing

Dentistry is an active profession.

We diagnose, restore, extract, replace, reshape, reconstruct, and rehabilitate. Our education is built around problem-solving, technical competence, and clinical intervention. From our earliest days as students, we are taught to identify pathology and formulate treatment plans. In many respects,

this approach is entirely appropriate. Patients seek our expertise because they want solutions.

But not every patient arrives seeking a specific procedure. Some arrive carrying fear. Others carry embarrassment after years of avoiding treatment. Some bring painful memories of previous experiences, and still others simply want reassurance that their concerns are valid and that they will be treated with dignity. And these concerns are not always immediately visible.

A radiograph may reveal extensive disease, but it cannot identify the patient who has postponed treatment for a decade because of severe dental anxiety. A periodontal chart may quantify attachment loss, but it cannot explain why a patient becomes unusually quiet when treatment options are discussed. Listening therefore, is far more than a social courtesy: It is a clinical skill.

Through listening, clinicians uncover fears, expectations, misunderstandings, cultural beliefs, financial concerns, previous experiences, and personal priorities that may profoundly influence treatment decisions and outcomes. Patient-centred care in dentistry repeatedly identifies communication, partnership, trust, and the recognition of individual needs as essential components of effective care. Perhaps this is why experienced clinicians often become



more deliberate during consultations. They learn to pause and they know when to ask one more question. They learn that silence occasionally reveals more than conversation. And they also learn that the most important information in a consultation is not always found in a clinical examination or a radiograph, but is found in the patient. Some of the most important discoveries are made with neither an instrument nor a handpiece, but simply by listening carefully enough to hear what the patient is truly trying to say.

4. Communication is not a soft skill

Dentistry has traditionally separated clinical competence into distinct domains:

There are the hard skills: diagnosis, treatment planning, surgery, restorative procedures, radiographic interpretation, and the countless technical competencies that define our profession.

And then there are the soft skills: communication, empathy, listening, and interpersonal relationships.

The terminology seems harmless enough, but words matter. That is, when we describe communication as a soft skill, we risk implying that it is somehow optional or an enhancement rather than a necessity.

The reality is rather different. Communication influences almost every aspect of clinical practice. It affects whether patients understand their diagnosis. It influences informed consent. It shapes treatment acceptance, adherence, anxiety, trust, and satisfaction. It determines whether patients return for follow-up care and whether they feel sufficiently comfortable to disclose concerns that may directly influence treatment outcomes. In many respects, communication is woven into every stage of patient care.

Perhaps nowhere is this more evident than when discussing treatment options. Dentists often assume that the primary challenge is selecting the correct treatment. Patients, however, may be wrestling with entirely different questions: Can I afford this? Will it hurt? Can I trust this recommendation? What will happen if I do nothing?

These questions don't appear on a treatment plan, yet they often determine whether treatment proceeds at all.

This is why patient-centred care has become such an important concept within contemporary healthcare. It moves the consultation away from a purely transactional model (one in which information is delivered and decisions are made) and towards a collaborative relationship built upon communication, partnership, and mutual understanding. Interestingly, reviews of the dental literature suggest that these very principles remain incompletely defined and inconsistently applied within dentistry itself.

Perhaps the greatest misconception is that communication simply involves transferring information from one person to another. Experienced clinicians know that this is rarely the case and that communication is interpretation and even reassurance. Communication is understanding not only what patients say, but what they hesitate to say. Dentistry often celebrates the treatment that changed a tooth. Patients celebrate the conversation that changed their minds. And perhaps this is why some of the most respected clinicians are not necessarily remembered for their technical brilliance

alone, but for therapeutic relationship successes because of communication, and there is nothing soft about that.

5. Perhaps the consultation is the treatment

There is a familiar scene that unfolds in dental practices every day when a patient sits in the chair and says, "I've been meaning to come in for years." Sometimes, those words are followed by an apology. Sometimes, by embarrassment. Occasionally, by tears. Usually the clinical findings are obvious: extensive caries, advanced periodontal disease, missing teeth, a fractured restoration, or a painful abscess. Yet the biological diagnosis is often only one part of a much larger story.

Why did the patient wait? What were they afraid of? What previous experience convinced them that avoidance was preferable to treatment? These questions are rarely answered by radiographs or clinical examinations. As we know, they are answered through conversation.

Perhaps this is why the consultation deserves to be viewed differently. It is not merely an administrative requirement preceding treatment, nor simply an opportunity to obtain a history and secure informed consent. It is the moment in which uncertainty begins to give way to understanding, and in which anxiety can gradually be transformed into trust.

Contemporary healthcare increasingly recognises the importance of shared decision-making, acknowledging that patients are not passive recipients of care, but active participants in decisions affecting their health. The consultation therefore grows beyond information exchange into a collaborative process through which patients and clinicians develop a shared understanding of problems, priorities, expectations, and goals.

Experienced clinicians understand this instinctively when they recognise that the frightened child may need reassurance before treatment can begin. They know that the patient who repeatedly misses appointments may not be non-compliant, but fearful. They appreciate that the technically ideal treatment plan may not be the treatment plan that best aligns with a patient's circumstances, values, or priorities.

Early in our careers, we may understandably be preoccupied with procedures. We focus on technical competence, efficiency, and execution. Later, many of us begin to understand why and how some of our most meaningful clinical successes occurred long before an instrument was ever placed into a patient's mouth. And perhaps that is the profession's quietest lesson: The restoration matters. The surgery matters. The diagnosis matters. But years from now, very few patients will remember the probing depths we recorded or the material we selected. They will remember whether they felt respected. They will remember whether they were heard.

And perhaps that is why the consultation remains the most important procedure we perform.

CONCLUSION

Perhaps one of the most interesting aspects of clinical practice is that, over time, our understanding of success begins to change. Early in our careers, we understandably focus on technical proficiency. We refine our clinical skills, pursue

efficiency, master procedures, and measure outcomes. These are the foundations upon which our profession is built, and they remain indispensable.

Experience has a curious way of broadening our perspective. The cases that remain with us are not always the most technically demanding. More often, they are the patients who taught us something about ourselves. The anxious patient who finally agreed to treatment. The child who left the practice smiling. The individual who returned after years of avoiding dental care. The family that continued to place its trust in us over decades.

These memories rarely centre on a restoration, an extraction, or a radiograph. They centre on people. Maybe this is why the consultation deserves to be reconsidered, not as a preliminary exercise preceding treatment, but as a therapeutic encounter in its own right. Contemporary dentistry increasingly recognises that communication, trust,

and partnership are not peripheral to clinical care; they are among its defining characteristics.

To me there is something reassuringly timeless about this observation. Long before digital dentistry, artificial intelligence, three-dimensional imaging, and guided surgery, there was a conversation between a patient seeking help and a clinician offering it. There still is.

Years from now, very few patients will remember the clinical jargon and procedures, but they will remember how you made them feel. Perhaps that is why the consultation remains the most important procedure we perform.

Because before there is a diagnosis, before there is a treatment plan, and before a single instrument is lifted, there is a conversation. And in that conversation lies one of dentistry's greatest opportunities: not merely to treat a mouth, but to care for a person.

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SADA Welcomes Constitutional Court Judgment on the Certificate of Need

SADJ JULY 2026, Vol. 81 No.6 P366

Mr KC Makhubele – CEO, South African Dental Association

The South African Dental Association (SADA) welcomes the recent judgment of the Constitutional Court declaring sections 36–40 of the National Health Act, commonly referred to as the *Certificate of Need* provisions, unconstitutional. The decision represents a significant development for healthcare practitioners and reinforces important constitutional principles relating to professional autonomy, patient rights and the regulation of healthcare services in South Africa.

Since the introduction of the Certificate of Need provisions, SADA has consistently maintained that the proposed framework posed substantial constitutional, operational and practical challenges for oral healthcare practitioners. The Association submitted formal representations to the National Department of Health outlining its concerns regarding the broad discretionary powers that would be conferred on the Director-General of Health and the potential implications for the sustainability of dental practices, patient access to care and professional independence.

SADA further articulated these concerns during its submissions to Parliament's Portfolio Committee on Health on the National Health Insurance (NHI) Bill. The Association cautioned against regulatory mechanisms that could unnecessarily restrict healthcare professionals' ability to establish and operate practices while limiting patients' freedom to choose their healthcare providers. SADA also participated in broader healthcare sector collaborations that supported legal challenges to the Certificate of Need provisions.

In its judgment, the Constitutional Court concluded that the impugned provisions unjustifiably infringed several constitutional rights by granting excessive regulatory

authority to the Director-General of Health. Importantly, the Court declared the provisions invalid in their entirety rather than suspending the declaration of invalidity or referring the legislation back to Parliament for amendment.

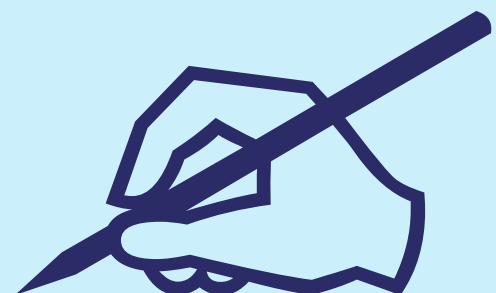
The judgment affirms the constitutional principle that legitimate healthcare reform must remain consistent with the rights enshrined in the Constitution. While equitable access to healthcare remains a national imperative, SADA continues to advocate that such objectives should be achieved through collaborative policy development, investment in healthcare infrastructure, workforce planning and evidence-based reforms rather than through disproportionate regulatory restrictions on healthcare practitioners.

Although the Department of Health has indicated that the ruling does not directly affect the National Health Insurance Act, the Constitutional Court's reasoning highlights broader constitutional principles that remain relevant to ongoing discussions surrounding healthcare reform. These include the appropriate limits of executive authority, protection of professional and commercial freedoms, preservation of patient choice and the practical implications of regulatory frameworks on access to quality healthcare services.

SADA remains committed to constructive engagement with government, Parliament, professional associations and other healthcare stakeholders to advance policies that strengthen South Africa's healthcare system while respecting constitutional rights. The Association believes that sustainable healthcare reform requires partnership, sound governance and evidence-based policymaking to ensure that all South Africans continue to have access to safe, affordable and high-quality oral healthcare.

CPD questionnaire on page 424

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.



Perceptions of Occupational Health Integration in Dental Assisting Education: A Qualitative Two-Province Study in South Africa

SADJ JULY 2026, Vol. 81 No.6 P367-P373

FF Kokela,¹ R Moodley²

ABSTRACT

Background

Dental professionals are exposed to several occupational risks and hazards, including musculoskeletal disorders, biological exposures and psychological stress. These exposures highlight the critical need for curriculum frameworks that adequately prepare students to manage these challenges across diverse training environments.

Objectives

This study aimed to examine academic staff perceptions of occupational risks and hazards incorporated into dental assisting curricula, and to evaluate the extent to which self-care practices are integrated into dental education and training.

Methods

A qualitative research design was employed to explore the perspectives of academics who teach content related to occupational health risks and hazards in dental assisting programmes. Six academics from two provinces participated in the study. Data were analysed thematically using Braun and Clarke's reflexive thematic approach.

Results

Themes such as self-care, radiation safety, education and training, infection control and ergonomics were identified. Participants recommended that dental assisting curricula be modernised by integrating technology, aligning them with the standards set by the Health Professions Council of South Africa, and adopting an interdisciplinary approach to occupational health education.

Conclusion

Despite data being gathered from only two provinces, the findings indicate that dental assisting curricula should provide comprehensive coverage of workplace occupational risks and hazards to better equip students for the demands of professional practice.

Keywords

dental assistants, dental education, occupational health, occupational hazards, risks, curriculum

INTRODUCTION

Dental professionals, including dental assistants, are routinely exposed to a broad spectrum of occupational health risks, including biological, chemical, physical, ergonomic, and psychological hazards, as well as radiation exposure, musculoskeletal disorders, stress, and burnout.¹ These hazards frequently arise early in clinical training in dentistry education, increasing the potential for harm to both facilitators and students. Throughout the program, students' perceptions of the educational environment decline, particularly throughout the pre-clinical and clinical phases²

Self-care

There is growing concern that key preventive elements may not be adequately incorporated into dental curricula.³ Additionally, the dental personnel continually experience difficult and stressful circumstances that may have a detrimental effect on their mental, emotional, and physical health.⁴ According to the World Health Organisation (2022), stress at work has been demonstrated to have a detrimental effect on productivity, particularly focus problems and a higher chance of major repercussions like failing to identify health issues that are contraindicated and patient-related safety concerns.⁵ Self-care refers to intentional and purposeful efforts to safeguard one's physical, mental, and emotional well-being, including proactive measures to manage stress and promote personal health.⁴ Woo *et al.* (2024) are of the view that dental practitioners who prioritise self-care are better able to interact with patients, make informed treatment decisions, and provide excellent care.⁴ In agreement, a healthy oral health care practitioner is essential for good patient care and must be able to perform this work for an extended period.⁶

In the context of dental assisting specifically, these risks are compounded by the dual demands of clinical and administrative work.⁷ Due to the nature of both clinical and administrative duties, dental assistants are exposed to a variety of occupational hazards.⁷

These risks are categorised as ergonomic, chemical, physical, biological, and psychological.⁷ Dental assistants' health, safety, and general quality of life may be impacted by these occupational risks and hazards, underscoring the significance of thorough education, training, and preventive measures in dental assisting programs and clinical practice settings.⁷

Author's information

1. Feziwe Flora Kokela, MMedSci. Discipline of Dentistry, University of KwaZulu-Natal, Private Bag X54001, Durban, 4001, South Africa
2. Rajeshree Moodley, PhD. Discipline of Dentistry, University of KwaZulu-Natal, Private Bag X54001, Durban, 4001, South Africa

FFK: 0009-0008-3068-2117; RM: 0000-0003-2703-9370

Corresponding author:

Feziwe Flora Kokela
University of KwaZulu-Natal
Email: kokela@cut.ac.za
email: 200104710@stu.ukzn.ac.za

Radiation safety

A study by Modiba *et al.* (2025) found that inadequate radiation protection training and irregular dosimeter use are associated with insufficient radiation protection practices in South African healthcare facilities. The Modiba *et al.* (2025) study further found that dental practitioners underestimated the detrimental health consequences of radiation exposure for patients and themselves.⁸

Due to the frequent use of diagnostic imaging, radiation safety remains a crucial aspect of dental practice, yet gaps persist in how this information is taught and reinforced in curricula. Dental professionals in South Africa must adhere to stringent regulations set by the South African Health Products Regulatory Authority (SAHPRA) to ensure patient and practitioner safety, especially regarding the use of radiation.⁹ Dental professionals are prohibited from installing or using X-ray equipment under the Hazardous Substances Act (Act 15 of 1973) unless they have a valid license for a particular user, machine, and location. These licenses are non-transferable (South African Dental Association, 2020).

Given the proven negative consequences of ionising radiation, SAHPRA's radiation control mandate places strong emphasis on reducing risks associated with exposure to patients, employees, and the public through adequate education, adherence to safety regulations, and the deployment of protective measures.⁹ When taken as a whole, these specifications strengthen the accountability, safe practices, and regulatory compliance of South Africa's dental radiography industry (South African Dental Association, 2020).

The Health Professions Council of South Africa (HPCSA) states that in accordance with the Health Professions Act (Act 56 of 1974) and related regulations, dental assistants are responsible for carrying out clinical and administrative tasks while being supervised by an oral health practitioner (South African Dental Association, 2020), however; the scope of practice for dental assistants is currently being reviewed as they are currently not permitted to perform X-rays except in the processing stage.

Dental assisting curriculum

Students' readiness to handle occupational risks in dental assisting is greatly influenced by curriculum development. However, there is little literature on how academics, who are crucial to the creation and delivery of curricula, perceive the inclusion and sufficiency of radiation protection and self-care in dentistry education programs, especially in the South African context. Thomas (2024) indicates that the available evidence suggests that clinical skills have historically taken precedence over workplace wellness and health in dentistry curricula, frequently leading to an inadequate focus on personal wellness and preventive measures.¹⁰

Research from South Africa shows that a large percentage of dental graduates reported limited exposure to ergonomics, stress management, and self-care during their training, indicating severe gaps in workplace wellness curriculum.¹¹ To provide safe clinical practice, curriculum design must incorporate fundamental concepts like rationale, optimisation and standardisation.¹²

Biradar and Narayan (2018) suggested that awareness of and implementation of preventive techniques can help create

a safe dental environment for everyone involved.¹³ All these gaps highlight the need for a more comprehensive and purposefully created dentistry curriculum that incorporates radiation safety and self-care as basic competencies, guided by the viewpoints and experiences of academics in charge of curriculum implementation.

Theoretical framework

In this study, Vygotsky's Sociocultural Theory guided a review of academics' perspectives on curriculum content, instructional methods, and learning environments.¹⁴ Vygotsky's theory holds that learning and knowledge acquisition occur through social interaction, shaped by historical, institutional, and cultural contexts.¹⁵ This framework is particularly relevant for understanding how dental assisting students acquire, interpret, and apply knowledge related to occupational risks within structured educational and clinical environments.¹⁴

While Vygotsky's theory addresses the social and contextual dimensions of learning, the Experiential Learning Theory complements this by explaining how knowledge of occupational hazards is built through direct experience.¹⁶ According to Kolb's Experiential Learning Theory, learning happens over a cycle of practical experience, conceptualisation, and exploration.¹⁶ Students can get practical understanding of risks like infection, radiation, chemicals, and physical strain in dental assisting by being exposed to actual clinical settings. Students' safety habits, hazard awareness, and adherence to regulations are shaped by the academics, clinicians, and peers they encounter in dental clinical environments. Gaps between theoretical instruction and real behaviour may result from inconsistent demonstration of safe practice.¹⁶

This study set out to investigate academic staff perceptions of the inclusion of occupational risks and hazards within the dental assisting curriculum, and to evaluate the extent to which self-care practices are integrated into dental education and training.

METHODOLOGY

Research design and setting

This was a descriptive qualitative study conducted in KwaZulu-Natal and the Free State among a focus group of academics who facilitated lectures to student dental assistants. Finding patterns in people's thoughts and views, as well as delving deeper into a subject, are common uses of qualitative research.¹⁷ The Human and Social Science Research Ethics Committee of the University of KwaZulu-Natal granted ethical permission (HSSREC/0000/4922/2022). All UKZN HSSREC rules and guidelines were followed during the study, and the relevant heads of department granted gatekeeper permission. It must be noted that the larger phase of this research has reported on occupational risks and hazards among dental assisting professionals; only two objectives were addressed in this study.

Data collection process

Six academics were purposively sampled to participate in this study. Purposive sampling was employed to ensure participants had more than two years of clinical and academic experience relevant to the study objectives. Prior to data collection, each participant received a participant information sheet and consent form. Participants consented to audio recording of the interviews and were informed of their right to withdraw at any time without penalty.

Table 1. Participants demographics

	Age (average)	Position/ Qualification	Years of experience (average)	Curriculum development experience
Focus group- Academics	30-43	Lecturers and clinicians (1 dentist, 2 dental assistants, 2 oral hygienists, 1 dental therapist)	2-13 years	5 participants had been involved in curriculum design

The verbatim transcriptions of the audio recordings were validated for correctness through member checking, to add rigour to the study.

To ensure confidentiality and anonymity, codes were assigned to both participants and institutions during data processing and reporting. Participants were identified as Participant 1 (P1) through Participant 6 (P6), and the study sites were designated as Institutions 1 and 2. Semi-structured interviews were conducted by the researcher, lasting 18 to 20 minutes each. Audio recordings were transcribed verbatim, and member checking was employed to verify transcription accuracy and enhance the rigour of the study.

Data analysis

Interview data were analysed using Braun and Clarke (2019) reflexive thematic analysis.¹⁸ This approach was selected for its flexibility in generating themes inductively from participant data, without imposing a pre-existing theoretical framework. Data extracts were inductively coded from interview transcripts, and themes were constructed to reflect academics' perceptions of dental assisting curricula regarding self-care, occupational risks, and institutional alignment in the South African context.

RESULTS

Introduction

Table 1 above summarises the demographic details of the participants. The average years of the academics ranged from 30 to 43 years. Most academics were clinicians with qualifications in dentistry, dental assisting, and oral hygiene, and had experience in curriculum development. A brief

description of the themes is provided in **Table 2**, followed by illustrative supporting quotes from the participants.

The findings were supported by responses to the interview questions. Participants shared their perceptions, providing deeper insight into the factors influencing the dental assisting curriculum. Below are the themes that emerged from the data analysis.

Occupational Risks and Hazards in the Curriculum

The participants were asked to reflect on the inclusion of occupational risks and hazards in education and training.

They suggested the following:

"I would say we address that in various modules in TPB 5000; we have occupational health and safety. In theory there is TAT 5000; there is also a part that teaches them about hazards like working with mercury. As part of clinical emergencies, they do first aid training, and a module that teaches them on occupational hazards" (Institution 1, Participant 3).

"We have the needle prick protocol that is included in our first aid course, and in medical emergencies. Disposal, we have protocols put around our clinic" (Institution 2, P4).

There was a suggestion on the inclusion of ergonomics during training: *"Ergonomics, in chapter two of TAP 5000, they deal extensively with that and various positioning, patient positioning and themselves around the patient. Yes, so one thing that we stress a lot that is their eyesight and their backs" (Institution 1, P2).*

Table 2: Participants' Reflection on Chemicals, Self-care, Radiation and Curriculum

Theme	Questions	Supporting statements
1. Chemicals Exposure	<i>Participants were asked whether chemicals were present in the clinic and whether students were exposed to them during training.</i>	"Yes, we have, especially when we do our manual processing of X-rays, so we do have chemicals" (<i>Institution 2, P5</i>). "The chemicals that we have are your normal disinfectants, sanitiser and your hand soap. We don't have any chemicals" (<i>Institution 1, P3</i>). "Yes, they do. We have holding solution, sterilant, we have disinfectant, we also have solutions for when you are taking the X-ray, the developing solutions, the fixer as well as the developer" (<i>Institution 2, P6</i>).
2. Self-Care in Modules	<i>Participants were asked to discuss how occupational health and self-care featured in dental curriculum.</i>	"The thing that we emphasise a lot, especially when they go out, is safety when using X-rays. It is needle prick injuries, and what needs to happen, we raise those ones a lot. Your posture when you are working and making sure that you are safe, and also the risk of sharps" (<i>Institution 2, P3</i>). "We teach infection control in both the theory and practical we teach infection control where we teach the students about looking after themselves, like proper use of your PPE. We bring in the value of vaccinating, also with the practical manual when we do stuff like suction control, we will teach them how to position themselves properly. Under four-handed dentistry and ergonomics- how to position yourself, where you are supposed to be" (<i>Institution 1, P2</i>). "The posture is important, sitting from 8 to 4 over the patients; even though the dental assistants have that chair, they still a bit crouched, and they sit in awkward position. Sometimes they are on their feet the whole day as well" (<i>Institution 2, P1</i>).

3. Student Well-being	<i>Participants were asked if any recreational activities would benefit the students.</i>	"We did the oral health campaign; from my own observation, I feel I became more approachable towards the students, because they felt they could have a conversation outside classes. In fact, some students even confided." (<i>Institution 2, P4</i>). "Institutionally, there is a provision for that. Student wellness, but within the program because we are only a one-year program, there isn't much time to investigate such." (<i>Institution 1, P3</i>).
4. Radiation Exposure	<i>Participants were asked about radiation exposure during students' clinical training.</i>	"Our X-ray is digital. So, we don't take X-rays manually at all" (<i>Institution 1, P2</i>). "Our students are not inside the room where the X-rays are being taken; they are usually outside. So, according to our knowledge, it is less. And we do provide a lead apron for our patient" (<i>Institution 2, P6</i>).
5. Student Radiation Exposure Levels	<i>Participants were asked about areas of X-ray chemical exposure during student training.</i>	"I don't have a number or amount. It is not a lot because we don't run a full clinic like in the big dental schools. So, it will probably be one per group of ten, fifteen students, round about. So, it is not a lot" (<i>Institution 1, P2</i>). "The radiation lady advised that the exposure from these units is very minute and that in terms of our lead lining on the walls, she told us it was okay to have a gap at the certain end of it." (<i>Institution 2, P4</i>). "Not necessarily because they are often not in the clinical area when we take X-rays, so I don't think they are exposed at all; if they are, it is very limited" (<i>Institution 1, P3</i>).
6. Curriculum Content	<i>The participants were asked if they are satisfied with the content that they facilitate.</i>	"With the content, I mean in this instance a true measure of satisfaction would be the student's feedback. So, I cannot say that I am satisfied or dissatisfied because I am not the recipient of the module itself" (<i>Institution 1, P1</i>). "Because it is more aligned to public institutions, there is not much of private parties preparing students for private facilities, so I would give it 5 on a scale of 10" (<i>Institution 1, P3</i>).
7. Clinical Training recommendations	<i>Participants were asked for recommendations they would make for dental assistant training.</i>	"Mainly we must consider the thing with the badges for X-rays, especially where they are going to be in practices where they are taking X-rays" (<i>Institution 1, P2</i>). CBCTs, get digital X-rays; also get the is Cam Scan, and they don't even know that, so when they go there, they don't know what it is. When you go there, you find that the dentist does implants as well as root canals, and there is nothing much we do practically on that. When you go out, students are being exposed to that. X-rays as well; everything is digital, even the processing; the manual processing is not there in some practices. (<i>Institution 2, P4</i>). "Smaller groups, more clinicians, just allowing students to be exposed to more. And a bigger clinical area that you can train. Because we need more clinicians, so we need more room for them" (<i>Institution 2, P5</i>).

Also recorded was the participant's response to the effectiveness of the training modules; there were clear discrepancies in their implementation and reinforcement.

They suggested:

"I think because we use an American book, sometimes the context is not the same; that's my number one problem. Number two, I think the scope of practice as the HPCSA one is not in touch with industry requirements. So sometimes you feel you want to satisfy industry, but you don't want to be against the scope; we could do better, we could improve" (Institution 2, P3).

Collectively, the results point to a deficiency in organised, hands-on, and ongoing workplace health and safety training, especially in various clinical contexts. These suggestions highlighted the necessity of standardised orientation programs, frequent updates on occupational risks, and practical health and safety training.

Discussion

This study explored academics' perspectives on the preparedness of the curriculum and the dental training offered

to students regarding occupational risks and health in their current positions. This study assessed the effectiveness, coverage, and impact of such training on workplace safety and well-being. To incorporate occupational risks and hazards into a dental curriculum, the researcher conducted focus group interviews with academics to gather feedback on the curriculum.

Dental curriculum

The participants reported occupational health-related injuries among students, highlighting the effectiveness of workplace safety measures in preventing such incidents. The use of gloves, masks, eye protection, and sterilisation procedures was recognised as routine infection control measures; however, due to inconsistent training and insufficient continuing education, participants suggested ways to protect dental assistants better and reduce workplace-related injuries.

A study supporting these views was conducted by Moodley and Van Wyk (2019), which found that inexperienced practitioners frequently experience stress, musculoskeletal conditions, and percutaneous injuries.¹⁹ There was

inadequate knowledge about occupational health regulations and processes that may guide safe dentistry practice in research in KwaZulu-Natal.¹⁹ The researcher engaged the facilitators regarding the level of satisfaction with the content and structure of the training modules they deliver. The effectiveness of preventive measures and ergonomic training to mitigate these risks during dental education was also explored. The participants agreed that the content quality and relevance of hazards in dentistry need improvement, as the scope of practice for dental assistants was not commensurate with industry needs. According to McHarg & Kay (2009), healthcare curricula need to be current, functional, and pertinent to the populations they serve, wherever those populations may be.²⁰ The academics in this study supported the notion for curriculum amendments, as an American book is used to facilitate lectures to South African students.

Self-care

The effectiveness of training and protective measures in safeguarding students' health, in collaboration with academics, was investigated. Additionally, the researcher assessed whether self-care practices were included in dental education modules. The participants cited modules such as "dental assisting theory" that support and promote students' well-being, including the importance of self-care in preventing burnout, stress, and physical strain, and in maintaining students' overall health throughout their training. According to Uziel *et al.* (2019), the health of dental staff and their patients may be affected by workplace fatigue and stress among dental assistants.²¹

This research explored the potential long-term effects of ergonomic hazards in dentistry, including musculoskeletal disorders, repetitive strain injuries, and posture-related health issues, as well as the risk factors, preventive measures, and interventions available to minimise musculoskeletal strain and fatigue. Participants complained about the long hours spent standing during the clinical sessions and the potential effects on physical health. In support of this, Khammissa *et al.* (2022) reported that, compared with fatigue-prone individuals, healthcare personnel who experience burnout are more likely to make mistakes and face medical malpractice claims.²²

Recommendations from the participants highlighted the importance of ergonomic interventions in promoting occupational health and well-being. These interventions should focus on factors such as workload, patient demands, and environmental challenges, as well as on coping strategies and support systems to help healthcare professionals manage stress and maintain well-being. In this study, educators' involvement in organising or encouraging recreational activities for students was also explored to support students' mental health, stress management, and overall well-being.

Radiation safety

This study further investigated the presence and use of radiation sources other than X-rays in dental training areas, as well as the levels of radiation to which dental students may be exposed during their education, including diagnostic imaging procedures and other radiation-related activities. The participants stated that potential risks, safety measures, and protocols were in place to protect students and staff from radiation exposure, including compliance

with regulatory standards as the industry has moved to digital diagnostic measures.

For note, the scope of practice for dental assisting students in South Africa currently does not allow them to take radiographs, according to the HPCSA.

Vilborne *et al.* (2021) found that there is a need to raise radiation awareness among South African dental professionals, and that dental imaging training should receive greater attention to raise awareness and understanding.²³ Another study conducted by Osazuwe-Peters *et al.* (2012) in Nigeria found that, when taking intraoral radiographs, 25.6% of participants used a film holder.²⁴ It must be noted that some of the skilled dental assistants still use this method in some of the practises in South Africa. Drawing on Kokela & Moodley (2024), similar results were observed, with the study suggesting enhanced communication about the safety facilities at training sites and increased adherence to protective measures during X-ray treatments.²⁵ Moodley & Van Wyk (2019) also concluded in their study that dosimeters should be added to track radiation exposure levels because dental radiography students and employees do not use them.¹⁹ As noted in the results, the procedures and protective measures implemented in workplaces to safeguard employees from infectious diseases were explored to evaluate their effectiveness, compliance, and the impact on health and safety. This study also assessed areas for improvement, the methods implemented to protect students from exposure to hazardous substances and clinical chemicals. Participants alluded to the non-compliance of personal protective equipment due to experience; this area of concern was cited in a study by Ahmad *et al.* (2016), where, due to discomfort and inconvenience during operations, particularly in hot situations, healthcare personnel were exposed to dangers; most of them were unwilling to utilise personal protective equipment.²⁶

Schoonwyk's (2023) article concluded that only 40% of dental assistants reported participating in infection control training and continuing professional development activities annually within their individual Oral Health Care Facilities.²⁷ In cohesion with our research, Devia *et al.* (2022) suggested that a thorough awareness of the numerous hazards could help develop better practices with improved personal health care.²⁸ These inputs further supported the addition of an occupational risks and hazards course for the students, and there were recommendations made regarding improving the curriculum for the safety of students during training. Participants in the current study also suggested including dental ergonomics and awareness as curricular topics, and numerous studies have supported this recommendation.

Vygotsky's Sociocultural Theory and Kolb's Experiential Learning Theory, which offer frameworks for understanding how dental assisting students acquire knowledge and competence regarding risks and hazards, informed the review of academics' views in this study. In line with Vygotsky's theory that learning is mediated through social interaction, guidance, and experience, the study identified strengths, gaps, and opportunities to improve the dental assisting curriculum and better prepare students for the challenges they might encounter in practice.

The study was further guided by Kolb's Experiential Learning Theory, which emphasises that students develop professional competence through ongoing

active experimentation, reflective observation, and real experience. Thus, academic viewpoints shed light on how classroom education, simulation labs, and supervised clinical experiences are designed to enable students to apply theoretical knowledge to real dental situations.

Together, these theories allowed the study to assess how experiential learning and social interaction influence curriculum implementation and equip dental assistants to identify, prevent, and manage occupational risks and hazards in clinical practice.

CONCLUSION

This study makes a unique contribution by focusing on systemic and curriculum deficiencies in occupational health and safety training rather than individual knowledge gaps.

The results highlighted that, although in South Africa regulatory and governmental frameworks provide a foundation for safe practice, execution disparities stemming from resource shortages, insufficient monitoring, and training shortages pose ongoing risks. The study's findings show that public knowledge of health risks and hazards is essential to ensure students have a safe working environment. This justifies the inclusion of occupational risks and hazards in education programmes and dental curricula. Coordinated action across education, policy, and practice is also needed to address the concerns. Additionally, research on execution, strengthened infection control measures, and radiation safety are needed to expand access to occupational health care and improve the curriculum.

Clinical relevance and recommendations

This is the first research study to evaluate academics' perceptions of the preparedness of the curriculum design for dental assistants. The results will be shared with the participants and presented to the universities, which may provide a basis for modifying the current teaching module to improve student outcomes and training services. Curricula for dental assistants should incorporate occupational health and safety throughout, emphasising applied, clinical scenarios over merely theoretical education. To reduce variation in training and practice, universities and standardised clinical training sites should implement consistent infection control and ergonomics guidelines.

The findings emphasise the need to go beyond simple compliance toward a long-term, systemic strategy for occupational health and safety, which will ultimately improve patient outcomes and practitioner well-being in dental settings. Although research recognises that knowledge does not always translate into action, the findings in this study may be addressed through occupational health hazard education, prevention strategies, improved training services, and further research into the topic.

Limitations of the study

The study participants were drawn from two sites, both of which are home to four institutions that train dental assistants; therefore, the small sample of academics (n=6) limits the depth of cross-institutional comparison, as the results do not represent all academics in South Africa. Despite its limitations, this study can shed light on the hazards and risks dental students face during training. Further research on occupational health risks and hazards among dental assistants is needed across other institutions in other provinces.

Acknowledgements

The researcher would like to thank the participants who contributed to this study.

Conflict of Interest

The authors declare no financial or personal relationship(s) that may have inappropriately influenced them to write this article.

Source of Support

The authors received financial support for the research and authorship of this article from the Department of Higher Education and Training (DHET) via the Research Grant and Scholarship Committee (UCDR R&D) from the Central University of Technology.

Contribution

The principal author (FFK) contributed substantially to the conception and design, as well as to data acquisition, analysis, and interpretation. The co-author (RM) assisted with study design, methods and data analysis. All authors critically revised the article for valuable intellectual content and approved the final version.

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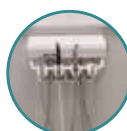
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Non fibre optic/Fibre optic with Hand Pieces

- 3 HP Automatic Hand Piece line unit
- 3-1 Syringe
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- Foot Control
- Master Shut off

Hand Pieces Included

- 1x illumination LED Handpiece with coupling Turbine
- 1x Internal spray straight handpiece
- 1x Contra angle blue handpiece
- 1x Air motor 4-hole
- 1x Prophylaxis handpiece



Built-in Compressor

Silent Oil Free Air Compressor

- Power: 0.75Kw(1HP)
- Air flow: 152L/min(5.37CFM)
- Air Displacement: 78L/min (1.77CFM) at 0.5MPa Noise: less than 68dB
- Tank: 30L Pressure: 8Bar(120Psi)
- Size: 410*410*640mm



1x Cleanwater System

Cabinet / Power Supply Specs

- The unit operate on 240VAC 50/60Hz fitted with SABS Plug
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The total occlusal convergence of dental preparations made by the students in preclinical training

SADJ JULY 2026, Vol. 81 No.6 P374-P377

M Amine,¹ Z Al Jalil,² B Maftouh,³ A Boualam,⁴ D Chari,⁵ M Hamza,⁶ S El Arabi⁷

ABSTRACT

Introduction: The basic principles of preparation of fixed prostheses are essential. Retention is one of the mechanical principles; it depends on several parameters, including the occlusal convergence of preparations.

Objective

To evaluate the total occlusal convergence (TOC) of crown preparations executed during practical work by students of the Faculty of Dentistry of Casablanca (FDC).

Materials and methods

420 preparations made by second-year FDC students were scanned by DENTAL WINGS, SERIES 3. The STL digital files were read by the 3D-TOOL-FREE software. Two images were extracted using the screen capture tool, and the medio-distal (MD) and bucco-lingual (BL) angles were measured using MB-RULER (MB Software, Germany). Data were analysed using the SPSS software (IBM Corp, Armonk, NY) and the comparisons were made by the Student t test.

Results

The TOC was reproduced, within an acceptable range of 6°–16° in 80.3% of the cases. A mean value of 13.00° ±

3.58° was found, with 10.78° ± 3.73° in MD and 15.24° ± 4.56° BL.

Conclusion

Students are able to produce recommended TOC angles for cast and metal-ceramic crowns.

Clinical relevance

The principles of preparation are fundamental to the success and durability of fixed restorations.

Key words

Convergence angle; Crown preparation; Dental student; Practical session

INTRODUCTION

The teaching of dentistry is based on theoretical teaching associated with practical session and clinical activity.

The dental preparation, with a view of achieving crowns with total coverage, is a competence that should be validated in preclinical.

Tooth preparation is done by reducing the tooth structure on all faces (B, Buccal, L, lingual, M, medial, D, distal, O, occlusal) of the clinical crown. Total occlusal convergence (TOC) is the angle between the opposite axial surfaces of the prepared tooth.

The principles of preparation are fundamental to the success and durability of fixed restorations. A slight conicity of the stump is necessary for insertion of the prosthetic element. However, excessive convergence is detrimental to its retention.

Ward, 1926 was one of the first to recommend convergence as such, prescribing 3 to 12 degrees.¹ Jorgensen² and Kaufman *et al*³ demonstrated experimentally that retention decreases as taper increases.

Several techniques have been described so far to evaluate the angles of convergence of the preparations, photographic cameras, overhead projectors, goniometric microscopes, CAD/CAM machines.⁴⁻⁸ Several studies published in recent decades have measured the angles of convergence of dental preparations performed by general dentists and students attempting to produce the recommended values in simulation or preclinical environments. However, all studies reported significant TOC angle values, which led to an increase in the angle recommendation to a more clinically feasible value.

Today, a total convergence of 16° has been proposed as clinically feasible while providing adequate retention.⁹

Authors' information:

1. Meriem Amine. Professor, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Department of Fixed Prosthodontics, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: drmeriemamine@gmail.com
2. Zineb Al Jalil. Professor, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Pediatric dentistry and epidemiology, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: zaynab30112000@yahoo.fr
3. Boutaina Maftouh. Assistant Professor, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Department of Fixed Prosthodontics, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: bouthaina.mft@gmail.com
4. Ayoub Boualam. DMD, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Fixed Prosthodontics Unit, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: blm.ayoub@gmail.com
5. Donia CHARI. DMD, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: douniachari@gmail.com
6. Mouna HAMZA. Professor, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Mouna HAMZA Pediatric dentistry and epidemiology, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca Email: mounahamza@yahoo.fr
7. Samira EL ARABI. DMD, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Department of Pediatric Dentistry, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca. Email: Samiraelarabi@gmail.com

Corresponding author:

Name: Maftouh Boutaina
Address: Department of Fixed Prosthodontics, Faculty of Dentistry of Casablanca, Hassan II University of Casablanca, abou alaa Zah street Casablanca, Morocco, 21100
Email: bouthaina.mft@gmail.com
Phone number: 00212 693421817
https://orcid.org/0009-0006-7096-7294

Are students able to reproduce, in preclinical, recommended occlusal convergence angles for sealed unit preparations?

Goal: To evaluate the total occlusal convergence (TOC) of crown preparations carried out in practical work by second year students of the Faculty of Dentistry of Casablanca (FDC).

MATERIAL AND METHODS

Study design and participants

This observational study included 420 crown preparations performed by 71 second-year dental students from the Faculty of Dentistry of Casablanca (FDC).

Study setting

All procedures were carried out during preclinical practical sessions at the simulation laboratory of the FDC.

Data collection procedure and measurements

Prepared teeth were scanned using the Dental Wings 3-series scanner, producing digital images in STL format. These files were opened using the 3D-TOOL-FREE software, and two screenshots were captured for each preparation: one from the bucco-lingual (BL) view and one from the mesio-distal (MD) view.

The convergence angle (CA) of each section was measured using MB-Ruler software (MB Software, Germany). All measurements were recorded in a structured database. Statistical analysis

Means and standard deviations were calculated. Data were analysed using SPSS software (IBM Corp., Armonk, NY, USA). Student's t-test was used to assess differences according to gender, dental arch sector, tooth type, and type of preparation.

RESULTS

The sex ratio Female/male of students was 1.84. The sample consisted of 141 preparations on maxillary premolars, 139 on maxillary molars and 140 on maxillary incisors.

In total, two types of preparations were analysed; 211 preparations for cast crowns and 209 preparations for

ceramic-metallic crowns. The TOC average was $13.00^\circ \pm 3.58^\circ$. The mean BL angle of all preparations was $15.23^\circ \pm 4.56^\circ$, and the mean MD angle was $10.77^\circ \pm 3.73^\circ$ (Table I).

Table I: Mean and standard deviation of total occlusal convergence

	MD	BL	AVERAGE
Mean	10.77°	15.23°	13.00°
Standard-deviation SD	3.73°	4.56°	3.58°

MD medio-distal

BL bucco-lingual

A percentage of 80.3% of students achieved TOC values between 6° and 16° on average, 4.2% realised angles less than 6° on average and 15.5% achieved values above 16° on average. The mean TOC was $13.11^\circ \pm 3.38^\circ$ for female students and $12.79^\circ \pm 3.98^\circ$ for male students.

The mean BL and MD angles were $15.27^\circ \pm 4.11^\circ$ and $10.97^\circ \pm 3.49^\circ$ respectively for the preparations made by female students and $15.17^\circ \pm 5.38^\circ$ and $10.41^\circ \pm 4.19^\circ$ for preparations made by male students.

Comparison of TOC by gender by the Student test gave a p value of 0.72. (Table II)

The overall mean TOC was $11.19^\circ \pm 5.45^\circ$ on premolar preparations, $14.67^\circ \pm 6.42^\circ$ on molars and $13.49^\circ \pm 5.10^\circ$ on the incisors. The comparison of the values by the Student test gave a p value of $<10^{-3}$. (Table III) The overall TOC averages in the anterior area were $13.30^\circ \pm 5.14^\circ$ and $12.85^\circ \pm 4.29^\circ$ in the posterior area. Comparison of the values by the Student test gave a p value of 0.34 (Table IV).

Comparison of the TOC values of the $12.15^\circ \pm 4.78^\circ$ for cast crown preparations and the $13.86^\circ \pm 5.48^\circ$ for ceramic-metal crown with the Student test was significant with a p value $<10^{-3}$ (Table V).

Table II : Mean and standard deviation of total occlusal convergence by gender

	N	MD MEAN	SD MD	BL MEAN	BL SD	AVERAGE	AVERAGE SD	P-VALUE
FEMALE	46	10.97°	3.49°	15.27°	4.11°	13.11°	3.38°	0.721
MALE	25	10.41°	4.19°	15.17°	5.38°	12.79°	3.98°	

MD medio-distal

BL bucco-lingual

Table III: Mean and standard deviation of total occlusal convergence by tooth type

	N	MD MEAN	MD SD	BL MEAN	BL SD	AVERAGE	AVERAGE SD	P-VALUE
INCISOR	140	9.32°	4.89°	17.29°	6.83°	13.49°	5.10°	<10 ⁻⁵
PREMOLAR	141	9.71°	6.73°	12.67°	5.77°	11.19°	5.45°	
MOLAR	139	13.46°	7.27°	15.88°	7.05°	14.67°	6.42°	

MD medio-distal

BL bucco-lingual

Table IV: Mean and standard deviation of total occlusal convergence by sector

	N	MD MEAN	MD SD	BL MEAN	BL SD	AVERAGE	AVERAGE SD	P-VALUE
ANTERIOR	140	9.31°	4.88°	17.29°	6.82°	13.30°	5.14°	0.342
POSTERIOR	280	11.52°	5.06°	14.21°	4.84°	12.85°	4.29°	

MD medio-distal
BL bucco-lingual

Table V: Mean and standard deviation of total occlusal convergence by type of preparation

	N	MD MEAN	MD SD	BL MEAN	BL SD	AVERAGE	AVERAGE SD	P-VALUE
CAST CROWN	211	10.58°	5.96°	13.71°	5.13°	12.15°	4.78°	<10 ⁻³
CERAMO-METAL CROWN	209	10.94°	5.04°	16.79°	6.85°	13.86°	5.48°	

MD medio-distal
BL bucco-lingual

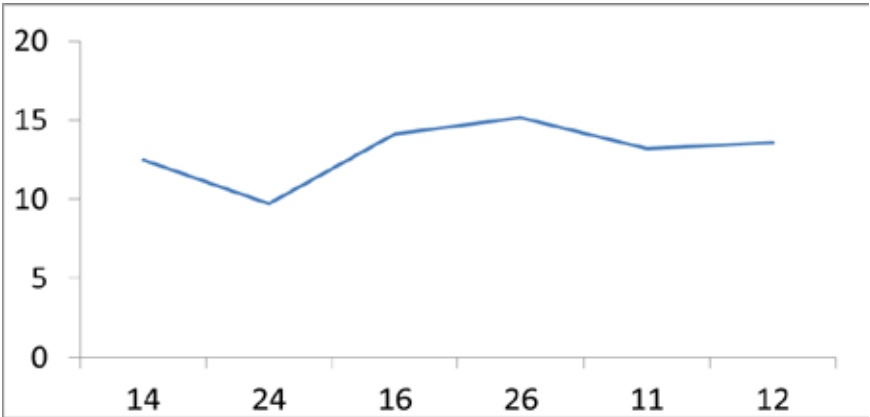


Figure I: Curve of evolution of TOC values of students during the academic year

The evolution of the average TOC values achieved by all the students in order during the academic year was plotted and represented in Figure I.

DISCUSSION

Retention is one of the fundamental mechanical principles for the preparation of sealed fixed prostheses; it depends on several parameters, including the occlusal convergence of preparations. A slight conicity of the stump is necessary for insertion of the prosthetic element, however excessive convergence is harmful for its retention.²⁻³

A total convergence of 16° was proposed as being clinically feasible while providing adequate retention.⁹

The study we conducted assesses the angles of convergence of the cast and metal-ceramics preparations of students in the second year of the faculty of dentistry of Casablanca (FDC). Various evaluation tools can be used such as photocopyers,⁴ cameras,⁵ overhead projectors,⁶ goniometric microscopes,⁷ CAD / CAM machines,⁸ etc.

We used an objective and reproducible method, actually the DENTAL WINGS 3 SERIES scanner has an innovative technology that combines laser triangulation with three or five motion axes, a multiple scanning capacity and an accuracy of 15 Microns, allowing the results to be compared with those of previous studies and those of future studies.

Our study reported an overall total occlusal convergence TOC value of 13.00°, with 10.78° in the MD direction and 15.24° in the BL. A percentage of 80.3% of students achieved values between 6° and 16°. This falls within the recommended range. Indeed, a total convergence of 16° has been proposed as being clinically feasible while offering adequate retention⁹

Our findings are similar to the work of Marghalani TY10, 2014 which found for dental students at King Abdulaziz University in Saudi Arabia TOC values of 11.11° in the medio-distal and 10.49° in Bucco-lingual.¹⁰

Other institutions around the world have recorded higher values;

Ohm and Silness, 1978 had analysed the preparations made by the students of the European dental school at the University of Bergen in Norway and found mean angles of convergence of 12.8° in the medio-distal and 22.5° in the bucco-lingual.¹¹

Noonan and Goldfoge, 1991 found, in a similar study conducted at a dental school at the University of Colorado in the United States, mean convergence angles of 19.3° in the mesial-distal and 20.1° in the bucco-lingual.⁴

Patel *et al*, 2005 compared the convergence of preparations made by students in Grades 4 and 5 with the clinical teaching

staff of the University of Sheffield in the United Kingdom. The mean values found were 27° in the MD and 24° in the BL for the 4th year students and 16° in the MD and 15° in the BL for the 5th grade students. Clinical staff reached mean values of 17° for MD and BL sections.¹²

Reisha N Rafeek, 2006 found in a study conducted at the school of dentistry at the University of Western India, a convergence angles of 20.3° in the mesio-distal direction and 18.3° in the bucco-lingual sense.¹³

In more recent studies using the scanner as a digitisation method, Alhazmi *et al*, 2013 noted values of 22.4° in the MD direction and 23.3° in the BL sense for students at the University of Toronto¹⁴ and Aleisa *et al* 2013 an overall TOC average of 18.56° for students of King Saud University.¹⁵

AMINE *et al*¹⁶ 2021, evaluated cast and metal-ceramic crown preparations on models and in the clinical position on a simulator, they found an overall mean TOC of 11.99° ± 4.48° for preparations on the typodont with 11.40° ± 5.09° in the MD direction and 12.58° ± 4.74° in the BL direction. For simulator preparations, an overall mean of 11.31° ± 4.16° was recorded, with 10.81° ± 4.29° in the MD direction and 11.80° ± 5.44° in the BL direction. No significant differences were observed when comparing preparations performed on the typodont and the simulator. A percentage of 68.6% and 74.3% of preparations performed on the typodont and simulator respectively fell within an acceptable range of 6-16°.¹⁶

Moussaria *et al*¹⁷ 2024, evaluated the total occlusal convergence (TOC) of preparations for cast crowns or metal-ceramic crowns on typodonts, revealing a mean TOC of 13.5° ± 4.92°, with specific values of 11.02° ± 5.31° in the mesiodistal direction and 15.99° ± 5.81° in the buccolingual direction. A total of 59.7% of students obtained results between 6° and 16°.¹⁷

Various complementary methods, such as the integration of virtual simulators into dental education, are recommended to improve preparation results. They offer a personalised learning approach, enabling students to progress at their own pace and potentially improve clinical performance.¹⁶

Comparison of TOC values by gender revealed a statistically insignificant difference (p value 0.721). These results were corroborated by other authors.^{10,14,16}

The value of TOC would not depend on the sex of the student.

By comparing the TOC averages of tooth types using the Student test, we found that the difference was significant (p-value <10⁻⁵). The results obtained by our study show that the TOC values of the premolars fit perfectly within the range of values proposed recently for premolars, which is 14° on average.⁹ Although molars have higher values than premolars, they remain within the range of proposed molar values of 17° in the MD direction and 21° in the BL direction.⁹ This is due to the fact that the molars tolerate more convergence since they have more contact surface.

The highest values were recorded in the BL direction of the incisors 17.29° which should be 10° on average.⁹ These results are similar to the values reported by Robert F Wright *et al*, 2014 in a study at Harvard University.⁶

However, our results show that the difference in TOC values remains insignificant by considering the anterior (incisor) and posterior (premolar and molar) areas. Yet the BL values of incisors remain high, this can be because of the anatomical shape of incisors and the complexity of the achievement of the Lingual / Palatal wall.

Contrary to our expectations, the TOC values recorded on the cast crown preparations were lower than those on the ceramic-metal crown preparations. This could be explained by the presence of more anterior teeth in the sample of the metal-ceramic crowns, or by the fact that students tend to tilt the cutter more when they reduce more.

Considering the evolution of students, the learning curve presents an irregularity at the beginning of the academic year and then a slight plateau defining the stabilisation of the learning. This shows that through repetition, students have improved and slightly stabilised at the end of the academic year.

CONCLUSION:

Respecting the fundamental principles of sealed prosthesis preparations is a skill to acquire in preclinical. The study we carried out among the students of the second year of the Faculty of Dental Medicine of Casablanca and whose objective was to determine the angle of convergence of the preparations made by these allowed us to make the following observations:

- The mean total occlusal convergence (TOC) achieved falls within the recommended values.
- No significant differences were found between the achievements of different sexes.
- The TOC values recorded especially on the BL faces of the incisors were considerably high.
- Students improved and slightly stabilised at the end of the academic year.

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Healthcare professionals' perspectives on interprofessional education and collaborative practice at selected multidisciplinary healthcare training centers, in Gauteng Province

SADJ JULY 2026, Vol. 81 No.6 P378-P384

M Morule,¹ S Singh,² A Bhayat³

ABSTRACT

Introduction

Interprofessional Education (IPE) and Interprofessional Collaborative Practice (IPCP) are essential strategies for enhancing teamwork and improving the quality of healthcare services. The objectives of IPE and IPCP are to create synergy, allowing groups of healthcare professionals from different disciplines to achieve greater outcomes by working together and sharing knowledge and experiences rather than working in silos. However, not much is known about healthcare professionals' perspectives on IPE and IPCP in clinical settings.

Aim

To explore perspectives of healthcare professionals on interprofessional education and collaborative practice at a multidisciplinary healthcare training Centre.

Design

A qualitative, explorative study design.

Method

A semi-structured interview was conducted to collect data. Fifteen participants were purposively selected to participate in the study. The interviews were transcribed verbatim, and data was analysed using thematic analysis.

Results

Four themes were identified: perception of IPE and IPCP; effects of IPCP on patient care; challenges to IPCP implementation; enhancing IPE/IPCP in training and support in healthcare. Key recommendations included teaching about the roles of other healthcare professions and interprofessional values such as respect, communication, teamwork, introducing IPE/IPCP modules and learning events early during training.

Conclusion

The results of the study revealed that participants have limited knowledge of IPE and IPCP and often referred to these concepts to multidisciplinary team approach. The study findings further highlighted the challenges to implementation of IPCP and suggested ways to address them. These results highlight a need to provide training for healthcare professionals to equip staff and foster collaboration within a healthcare environment.

Key words

Interprofessional collaboration, Interprofessional teamwork, Collaborative practice, Healthcare professionals, Care coordination, Continuity of care, Interprofessional education.

INTRODUCTION

Interprofessional collaborative practice (IPCP) occurs when multiple health professionals from different disciplines work together with individuals, caregivers, families and communities to provide quality care to patients and improve health outcomes.¹ IPCP utilises both the individual and collective skills and experience of team members, allowing them to function more effectively and deliver a higher level of care than when working alone. The demand for effective collaborative teams is crucial due to the increasing prevalence of chronic diseases and an aging population with complex needs. This requires comprehensive, continuous and coordinated care from various healthcare professionals.²

IPCP involves cooperation, mutual trust and respect among healthcare professionals. It facilitates the efficient use of healthcare services by improving the coordination of care, reducing service duplication, and promoting communication among the healthcare team.³ Most significantly, patients are more likely to receive the highest quality of care if healthcare professionals understand each other's roles and appreciate each other's skills.⁴ In addition, IPCP offers appropriate

Authors' contribution

1. Morule Mpho, Dip OH, PGCHE, Bed Hons (Education), MHPE, College of Health Sciences, Discipline of Dentistry, University of KwaZulu-Natal, Durban ORCID <https://orcid.org/0000-0001-7729-384X2>
2. Singh Shenuka, PhD, PhD, College of Health Sciences, Discipline of Dentistry, University of KwaZulu-Natal, Durban. ORCID <https://orcid.org/0000-0003-4842-602X>
3. Bhayat Ahmed, M Dent, MPH, MSc, Department of Community Dentistry, Faculty of Health Science, University of Pretoria, Tshwane. ORCID <https://orcid.org/0000-0002-8103-1233>

Corresponding Author:

Name: Ms. Mpho Morule
Phone numbers: ±27725350761
Facsimile numbers: None
E-mail address: mpmohotsepe28@gmail.com

Contribution Details:

1. M Morule- study conceptualisation, data collection and analysis, manuscript preparation, writing and final editing (60%)
2. S Singh – data analysis, manuscript preparation and editing and final approval (20%)
3. A Bhayat- data analysis, manuscript review, editing and final approval (20%)

referral patterns, better collaborative decision-making with patients, reduces the time and costs of hospitalisation, medical errors and decreases readmission rates. This approach enhances patient and job satisfaction and well-being among team members.⁵

To provide patient-centered, cost-effective and quality care, there is increasing evidence indicating that healthcare professionals (HCPs) need to be prepared to collaborate in interprofessional healthcare teams. This approach led to the introduction of Interprofessional Education (IPE) in various health sciences training institutions as a strategy that can strengthen health systems and respond to the increasing complexity within the health and social care sectors.¹ However, evidence shows that many healthcare professionals have little or no knowledge and exposure to IPE activities and feel ill-prepared to collaborate successfully to integrate healthcare delivery.

Various studies on IPCP have been conducted in academic training; however, healthcare professionals in practice are often not included. This is supported by findings that have highlighted a need for focused research on how to better integrate IPCP into daily clinical practice, as its implementation remains limited in many settings despite the benefits of IPCP.⁶⁻⁷ The authors suggest that further studies be conducted to explore the extent to which collaboration amongst healthcare professionals from different disciplines are taking place in community-based centers.

Zahara *et al.*,⁸ and Gillani *et al.*,⁹ stated that when healthcare professionals have a positive perception of interprofessional collaboration, there is a greater chance of successfully achieving the goals associated with its implementation.

The integration of IPCP into clinical practice in South Africa (SA) is still limited as healthcare professionals operate mostly in silos.⁷ A review by Mohamed *et al.*⁷ synthesised evidence from articles published between January 2017 and December 2021, focusing on qualitative studies involving health professionals with experience in IPCP, in South Africa. The review highlighted barriers and enablers to the implementation of IPCP, including key aspects of healthcare systems, management and team leadership. One of the global problems in healthcare services is that health services are not optimally integrated, in which different practitioners work in silos.¹⁰ The consequences of a fragmented healthcare system are associated with a large proportion of patient care is poorly coordinated. Therefore, interactive collaborative practice is increasingly seen as an important way of delivering quality service in fragmented healthcare systems.¹¹

The healthcare system in SA consists of a large, poorly funded public sector and a smaller, better-resourced private sector. The National Department of Health holds overall responsibility for healthcare, and specifically for the public sector across South Africa's nine provinces.¹² Gauteng province is one of the most urbanised and densely populated provinces.¹³ Nearly half of public health resources are allocated to district health services, which include primary healthcare clinics, community health centers and district hospitals. The SA healthcare system is faced with multiple challenges, including high workloads, staff shortages and limited infrastructural resources.¹⁴ It is also affected by ongoing societal challenges associated

with poverty and unemployment, the heavy burden of disease and the inequitable quality of healthcare service delivery.¹⁴

Given the rising system challenges and the overburdened public health system that is unable to accommodate the increased demand for healthcare, the need for sufficient interprofessional synergy is more crucial than ever. However, there are gaps in knowledge on perspectives of healthcare professionals on IPE and IPCP in clinical settings.¹⁵ Moreover, there have been few studies investigating this shared social cohesion between tertiary training institutions and the community training facilities. Therefore, exploring professional healthcare perspectives on IPE and IPCP in the healthcare facilities affiliated with academic training institutions is essential for closing the gap and fostering a collaborative healthcare environment. It is in this context that this study aimed to explore perspectives of healthcare professionals in practice on interprofessional education IPE and interprofessional collaborative practice (IPCP), based on their experience in the work environment.

METHODS AND MATERIAL

Study design

A qualitative, exploratory research design was implemented to explore the perspectives of healthcare professionals on IPE and IPCP.

Research setting

The research was conducted at three multidisciplinary healthcare facilities affiliated with the training institution where students in health sciences are placed for their clinical practice as component of the community engagement initiatives i.e., work-integrated learning, experimental service-learning and community-based learning.

Sampling and sample size

A purposive sampling technique using specific inclusion criteria was used to select fifteen healthcare professionals who were key informants from three (3) multidisciplinary healthcare centers in Gauteng. Inclusion criteria were healthcare professionals who are known to be at clinical platforms with students in the practical placements and during patient ward or community contact. Participants selected for the study were from the following health professions: Nursing, Occupational Therapy, Physiotherapy, Dentistry, Medicine, Clinical Medical Practice and Dietetics. Exclusion criteria included healthcare professionals that are not working closely with students in the clinic/ward and have no direct contact with student/patient supervision. Healthcare professionals who were not from one of the targeted professions such as radiographers, and those who did not give consent to participate in the study, were excluded from the study. There was no response from Dentistry.

Data collection tool

A one-on-one semi-structured interview was conducted with healthcare professionals from various disciplines using a schedule guide with pre-determined questions and prompts. The interview schedule comprised of 12 questions divided into three sections (IPE and IPCP knowledge, benefits, challenges), with prompting questions, for clarification, to encourage detailed answers. The interview question guide was guided by the questions used in previous similar studies.¹⁶

The interview guide included questions to ascertain participants' knowledge in IPE and IPCP, collaborative practice implemented at their facility, and attitudes towards IPCP, barriers and challenges experienced while in collaborative practice and possible recommendations towards improving student's preparedness for IPE and IPCP.

Data collection process

Appointments were made with departmental and clinic managers, as well as clinical coordinators to introduce the study and explain the purpose and procedures. Clinical staff members with experience of working in a multidisciplinary clinic were identified as key informants for the study through the manager/department's office. Follow-up meetings were held where managers/ coordinators introduced the researcher to staff members who have shown interest to participate in the study. Permission was sought to access participants' emails. Invitation to the study was emailed to potential participants together with informed consent. Members that responded, accepted the invitation and gave informed consent, were in total fifteen comprising of five healthcare professionals from each healthcare facility.

Participation was voluntary for all who were willing to participate, and a written informed consent, as well as permission to audio record the session, was obtained, before the interviews were conducted. Interviews were conducted face-to-face or online to accommodate those participants with tight working schedules and were working shifts, for whom online interviews were the most suitable space. Before commencement of the interview session, the researcher explained the purpose of the study and clarify the aim of the interview to all participants in detail. Participants were reassured that all information obtained would be treated with confidentiality and that they could feel free to discontinue participation at any time if they chose to. To ensure confidentiality, pseudonyms were provided to protect the identities of participants and their healthcare facilities.

All interviews were conducted between September 2022 and December 2022, with each interview lasting between 60 to 70 minutes long. Audio recordings of the interviews were transcribed verbatim by a professional service provider. An independent co-coder was appointed to check transcriptions and ensure precise data translations and interpretations of themes.

Pilot study

Content validity of the interview guide was tested through expert review by an academic colleague with extensive qualitative research and IPE and IPCP experience, ensuring alignment with the study's aims and the appropriateness, clarity and relevance of the questions. The guide was then piloted on two healthcare professionals and modified before study commencement. Data obtained from these two colleagues was not included in the study. Minor changes were made such as correcting the flow of questions, and two questions were combined as the responses yielded similar answers.

Data analysis

A thematic analysis was carried out, using the six-steps methodology described by Braun and Clarke (2006).¹⁷ The principal researcher reviewed all audio recordings

while simultaneously reading the transcripts to ensure the transcribed data was complete and accurate. Transcripts were read repeatedly for familiarisation with the data. This was done individually by the principal researcher and one independent co-coder who is a qualified qualitative data analyst. Once the coders had familiarised themselves with the data as well as generated initial codes, the two coders convened to compare and discuss the codes and themes identified.

ATLAS.ti v23, allowed the researcher to generate new codes as well as alter initial codes. Coding was done until no further codes were identified. During this process, the codes identified by the researcher were aligned with codes identified by the Atlas. The quotes from interviewees are presented in the text of the results section; participants' perspectives are illustrated by the quotes written in italics.

Measures to ensure trustworthiness

To uphold credibility, cross-check of the entire analysis process was conducted by the co-authors, and all verbatim transcribed data validation was facilitated by an independent qualitative research analyst to verify the data accuracy. Dependability was achieved by keeping complete and detailed records of the research process and documenting all analytical processes, including code evolution, theme development, interpretations and refinement decisions. To enhance confirmability, an audit trail which included raw data (audio recordings), interview transcripts, interview guide, evidence of methodological processes and transparent data analysis processes were retained. Transferability was strengthened by providing a full description of the research context, study participants and research process to make it possible for other researchers interested in transferring the study to another context. The COREQ checklist tool was used to assess and enhance the reporting of qualitative research, including interviews. This helped to ensure comprehensive and transparent reporting by covering aspects such as the research team, study methods, findings, analysis, and interpretations.¹⁸

Ethics approval

Ethics approval for the study was obtained from the National Health Research Database (NHRD) (GP_202208_095) and from the institutions' Research Ethics Committee (46/2022). Subsequently, site specific approvals were obtained from all the health services involved in the study. The participants' right to privacy and anonymity was ensured whereby their names and the facilities were protected, and they were given pseudonyms throughout the interview recording and reporting of results. Data obtained were stored in a well-secured laptop and copies of the dataset in ATLAS.ti software was password-protected and made accessible to only the study investigators, with access control to the professional transcriber and the data analyst.

RESULTS

Overall, 15 individual interviews were completed. Interviewees occupied junior and senior level positions and were from the following professions: Nursing, Dietetics, Occupational Therapy, Physiotherapy, Medicine and Clinical Medical Practice. Participants' experience in their profession ranged from 2 years to over 30 years. At the time of the interview, participants had been in their current roles for between 6 months and 20 years. Further participant characteristics are presented in Table 1.

Table 1: Demographic data of the participants and facility

Healthcare professions targeted for the study	Facility A	Facility B	Facility C
Medical Doctor	A1	No response	C3
Dietetician	A2	B1	C2
Occupational therapist	No response	B3	C1
Nursing	A 3 and A5	B4 and B5	C4 and C5
Physiotherapy	No personnel	B2	No personnel
Clinical Medical Practice	A4	No response	No response
Dentistry	No personnel	Decline: Not working with students	No personnel
Total Participants: 15	5	5	5

*Participants were coded alphabetically according to the facility and chronologically depending on the time when the interviews were carried out.

STUDY FINDINGS

The thematic analysis yielded four themes namely: perception about IPE/IPCP; effects of IPCP on patient care; challenges to IPCP implementation; enhancing IPE/IPCP in training and support in healthcare. The themes were further subdivided into subthemes. The themes are illustrated below with representative quotes.

Theme 1: Perception about IPE and IPCP

Subtheme: Knowledge of IPE/IPCP

Participants reported that they did not have formal academic knowledge of IPE and IPCP. However, they highlighted that IPE and IPCP should be patient-centered and that such care should be holistic.

"My understanding with regards to interprofessional education and collaborative practice is that it is when more than two professionals come together to work together." (B2).

Interprofessional collaborative practice was commonly reported as a multidisciplinary approach that is implemented at the healthcare facilities, as expressed by the following participants:

"So we call it the multi-disciplinary approach; when we collaborate with all the different professions." (B3).

Subtheme: Understanding of roles of other healthcare professions

Participants discussed the roles and responsibilities of various professionals, noting that this knowledge came from presentations made by disciplines that sometimes are held at their facilities and other activities that familiarised them with the roles of different professionals such as during patient interactions. Some participants commented that:

"I think there's some basic understanding, but I don't think we always have the full depth of what the contribution is that every professional can bring." (C1).

There was a level of agreement between participants that some students do know the roles and responsibilities of other professionals however it is perceived as knowledge at a basic level but at the practice/ experiential level, they observe gaps as expressed by the following participants:

"In all honesty, I think that there is a bit of lack, especially in exposure to the other disciplines and when I see the

Community service or students coming in; I see the big gap that exists. Because not many of them know exactly when to bring in the other team members." (B3).

Subthemes: IPCP implemented activities

Participants indicated that there are multidisciplinary team meetings that take place on a daily, weekly and monthly basis for joint decisions on patient care and health awareness projects. Even though not all the disciplines are represented due to other commitments including shortage of personnel in the facility, these meetings were regarded as opportunities for interprofessional collaboration. These were reflected in statements made by some participants:

"Okay, besides the referrals, there are these main health presentations here, where each multidisciplinary team will come with a patient case and then discipline interact on that, and all the professionals that are working here together with the students discuss the case." (A5).

"I think the ones that we have are the ward rounds usually takes place weekly. And the other activities that bring us together with other disciplines, is when we are doing campaigns and educational programs for example, breastfeeding awareness or diabetes awareness week." (B2).

Subtheme: Staff receptive towards IPCP

Most participants shared their experiences that there are some departments that are keen for collaboration and show a common concern for those that are still lacking behind. Some participants pointed out factors that affect their participation in IPCP activities. The following quote illustrates participants' responses:

"It varies, you really get those who are team players, not working in island or in silos and you get your non-team players, but I think most people are receptive, yes." (C2).

Theme 2: Effects of IPCP on patient care

Subtheme: IPCP benefits

Participants highlighted what they considered beneficial as a result of IPCP. From the interviews, it was evident that the participants valued IPCP for its ability to improve teamwork and collaborative practice, coordinate patient care, and shorten hospital stay. Participants highlighted a few examples of cases where collaboration among different disciplines led to positive health outcomes and promoted better patient healing:

"Having all these disciplines under one setting, at the interest of the patient, it is positive. I don't get to treat my patient incomplete. If maybe I treated the patient and my patient needs to see a dietician, a physio, I take the patient straight and is attended too." (A4).

However, a lack of communication and integration of services negatively impacts on patient care and led to unnecessary readmission of the patient was observed as commented by one participant:

"So, there are many instances where we have seen patients being discharged without us being informed who were not ready. And I think it is bad for the patient to be readmitted unnecessarily." (B1).

Theme 3: Challenges to IPCP implementation

Subtheme: Attitude and undermining other roles

Participants described a range of factors that are challenging and seen as barriers for effective IPE and IPCP.

"Another barrier is we have some professions that would look down on other roles. Or there would be lack of respect for your knowledge or your competency." (B5).

Although collaborative practice is implemented by some departments, some participants noticed some level of negative attitude towards others and the hierarchy within the teams where some disciplines are still perceived as important than others. Some participants illustrated this point by saying:

"The key barrier is, firstly, I do not know if I should call it human attitude. But we see that there is a hierarchical system at play in the hospitals." (B3).

Subtheme: Lack of communication and planned coordination

Lack of planned coordination of care was perceived as a barrier for implementing effective IPCP including communication for joint activity.

"It doesn't always look like we planned jointly, whereby you would perhaps plan one joint activity. For me it looks like we don't have a definite structure of communication." (A2).

Subtheme: Lack of space

Majority of participants commented that it is sometimes difficult to facilitate collaboration with other healthcare professionals due to lack of adequate space in their healthcare facility. Their responses were quoted as:

"The barrier is also the congestion or structural space. We don't have enough space to put all the disciplines together in one space for IPCP activity." (A3).

Subtheme: Role modeling

Participants emphasised the need for role modelling from leadership to guide students' behaviour and foster an environment of respect and trust. Participants echoed statements such as:

"Role modelling. In other words, if the supervisor does not think it is necessary to collaborate, if they do not see the role that the others can play. I think that could be your worse barrier." (B1).

Theme 4: Enhancing IPE/IPCP through training and support

Subtheme: Skills to be learned

Almost all participants consistently reported communication skills, respect for teamwork and understanding of roles of other professions as important skills to teach students. Participants echoed statements such as:

"Respecting other people that work with you or that are going to work with you. The patient cannot thrive on you alone. So, you have to know the roles of other people that you are working with. And of course communication skills." (C3).

Subtheme: Level of study

The majority of the participants indicated that they support an introduction to IPE and IPCP training of students at an early stage (or at junior level), so when the students start their clinical years, they are fully exposed and aware of other healthcare professional roles. Some participants highlighted the sentiments in the following excerpts:

"I would think, at earlier stages, that they can already perhaps do some of those projects that they do for Interprofessional Health Leadership module (IHL), perhaps they can already learn about each other's roles." (A2).

The participants recommended certain aspects that should be included in the undergraduate health sciences training to improve and support the IPE and IPCP implementation.

Participants suggested that:

"I feel like from the start of the course, they should be just the minimal module, something like a three-week short course whereby they combined all the disciplines and give a case to them to sort it as a multidisciplinary team, just to collaborate and try to understand what this one does and what the other one does". (C1).

Additionally, some participants alluded to the shortcomings in the collaborative practices from the healthcare facilities and suggested some form of staff recognition from the institution

"It's a big complaint from staff members in practice that they have to make effort to educate students, to support them, to mentor them, take them by hand and teach them work. When that effort is not recognised by the institution". (C4).

DISCUSSION

The results of our study reveal that participants perceived IPCP to be similar than the multidisciplinary approach; most participants quoted the term "multidisciplinary" instead of "interprofessional". The debate about the term multidisciplinary as opposed to the term interprofessional may indicate a lack of participants' understanding of these definitions. Dawe *et al.*¹⁹ suggest that the terms multidisciplinary and interprofessional are often used interchangeably often confusing their specific meanings to describe health care teams. While interconnected, each term carries a distinct meaning and is vital in shaping how healthcare professionals collaborate and deliver patient care.

In order to provide safe and effective care, there has been a move away from the term 'multidisciplinary teams' in which individual specialists, often independently work in relative isolation, to interprofessional teams. Whilst it is

acknowledged that the term 'multidisciplinary' relies on the use of knowledge and skills from different disciplines, it does not necessarily refer to an interaction between the disciplines.²⁰ On the contrary, interprofessional infers interaction and collaboration. As such, interprofessional collaboration provides advantages over a multidisciplinary approach in supporting patients and their families as it enables teams to maximise the skills of each health professional, share decision-making and responsibilities, and ultimately maximise positive outcomes for patients.²¹ This collaborative effort goes beyond mere information sharing; it involves the integration of diverse perspectives and expertise to provide the best possible patient care.²²

In terms of IPCP activities, the healthcare professionals in our study perceived presentations by the disciplines that are sometimes held at their facilities and multidisciplinary team meetings that take place on a daily, weekly and monthly basis, as opportunities for interprofessional collaboration. Similarly, Dawe *et al.*,¹⁹ argued that MDT working for most healthcare professionals involves daily, informal, sometimes unplanned, clinical and non-clinical interactions. However, it is suggested that true interprofessional collaboration is a skill which must be learned and practiced; hence it is now included in the undergraduate curriculum of many health science training. These arguments are consistent with findings by Chitsulo *et al.*,⁵ which revealed the need for formal IPE training prior to engaging with interprofessional activities to boost confidence and competencies for professionals to collaborate effectively. In addition, capacity development influences education and skill development, as well as attitudes and behaviors which are essential for IPCP.²³

In line with previous studies, our study found that a successful collaboration between healthcare professionals is positively related to improved health outcomes and quality of care.^{8,24} Participants in our study identified a complex of benefits of IPCP on patient care and attributed it to regular communication about planning holistic care which facilitated improvements in access to second opinions and advice, as well as adopted agreements for treatment regimes. Additionally the positive outcomes of IPCP resulting in shorter hospital stays concurs with findings from previous studies.²⁴⁻²⁵

Participants from all three centers consistently identified significant barriers to IPCP. These barriers include health professionals undermining each other's work, a lack of coordination in patient care, insufficient collaborative spaces, and negative attitudes that hinder role modeling. These ongoing challenges not only impact IPE but also hinder the effectiveness of IPCP, emphasising the need for solutions to foster and support a more collaborative healthcare environment.^{6,9,15} A review by Seaton *et al.*,²⁶ as well as findings from El-Awaisi *et al.*,²⁷ also highlighted the lack of planned coordination of patient care and lack of space as some of the dominant themes influencing interprofessional collaboration in primary health care. Muller and Couper⁶ argued that role models are not always available in the clinical setting which could disempower graduates to act as change agents and discourage interprofessional collaboration in the working environments. These findings reveal that the emphasis on improving collaborative practice should focus not on students alone, but also on clinicians at healthcare centers.

Shared space for collaboration was emphasised in previous studies. It is thus noted that the need for the interprofessional team to have a communal location would facilitate collaboration and increase the accessibility of team members to communicate.²⁴ Thus, efforts could target flexibility and shared leadership and joint activity planning between professionals. In the long term, however, the most promising option seems to rely on staff training, and more particularly on mentoring, an emphasis also made by participants from this study as well. To address the current challenges and improve IPE and IPCP, including attitudes towards other professionals and undermining other HCP roles, it is essential to break the fragmented practices that exist within the healthcare system and to reconcile the disconnect among various healthcare members. This can only be achieved through adopting a culture of IPE and IPCP values whereby interprofessional collaboration is the norm and role modelling is practiced by both institutional leaders and clinicians.

Samuriwo *et al.*,²⁸ argued that the lack of understanding of other healthcare professionals' roles and the contributions each profession can make to the patient-centered team has frequently resulted in misconceptions regarding the role and scope of practice of other health professions. These misconceptions have created hierarchies that are problematic barriers, thus limiting opportunities in creating IPE efforts as well as collaborative clinical practice.²⁹ A positive attitude towards engaging in IPCP is considered to be a facilitator to effective collaboration and can affect how professionals perceive each other's roles. An understanding of different professional roles in a healthcare system can optimise collaboration in the workplace.³⁰

This study reveals that understanding the perspectives of healthcare professionals regarding interprofessional education and collaborative practice is essential. These insights can significantly enhance teamwork and improve patient outcomes in our healthcare system. More importantly their insights are vital in shaping effective teamwork and driving improvements in patient outcomes within the healthcare system. More importantly the results of this study echoed previous research that emphasised the need to implement practical IPE earlier in undergraduate training and that it should be an integral part of each year's level and carried throughout the courses.

STRENGTHS AND LIMITATIONS OF THE STUDY

The study provides valuable insight into participants' perspectives towards IPE and IPCP, shedding light on their attitudes and current IPCP practices. The research identified gaps in IPE and IPCP knowledge as well as challenges in implementation of these practices. Thus information can guide planning for implementation and inform future research aimed at maximising the benefits of IPE and IPCP, ultimately improving quality healthcare services. While there are implementation challenges to consider, optimising IPE and interprofessional IPCP is crucial. By enhancing communication and fostering collaboration among healthcare professionals, we can significantly improve patient health outcomes. Investing in these areas will lead to better care and a stronger healthcare system overall. The findings of this current study can only be generalised to study participants rendering services at the community healthcare centers. More research is needed to ascertain

the perspectives of other health professionals that could influence how interprofessional collaboration is facilitated.

As a way forward, it is suggested that continuing training opportunities be provided for healthcare professionals in practice, focusing on strategies to promote IPE and IPCP, implement collaborative activities through seminars, online webinars and workshops. This is also important as their exposure to students and clinical teaching will not only address capacity building but will strengthen role modeling and mentoring skills. Further research evaluating the effectiveness of implementation of IPE and IPCP strategies would be beneficial to ensure IPCP is achieved and to add to the limited body of knowledge.

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CONCLUSION

The results of the study pointed out that members of health care teams have limited knowledge of IPE and IPCP and often referred to these concepts to multidisciplinary team approach. Supporting and strengthening IPE and IPCP will ensure health care professionals work together to provide holistic care and improve quality of healthcare services. This will require effective training to equip staff and foster collaboration within a healthcare environment.

ACKNOWLEDGEMENTS

The researcher would like to thank all the participants who took time to contribute to this study.

CONFLICT OF INTEREST

The authors declare that they have no personal or financial relationship(s) that may have inappropriately influenced them to write this article.

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An assessment of third-, fourth-, and fifth-year undergraduate students' perceptions of research at Hage Geingob Campus

SADJ JULY 2026, Vol. 81 No.6 P385-P390

AS Andreas,¹ SK Bere,² RT Muro³

ABSTRACT

Background

Students at the University of Namibia's (UNAM) Hage Geingob Campus have been carrying out research projects ever since the UNAM medical school came into existence. The objective of the study was to determine the perceptions of research among undergraduate students at Hage Geingob Campus and to establish differences in perceptions of research between third-, fourth-, and fifth-year undergraduate students.

Methodology

A descriptive cross-sectional study was carried out at the Hage Geingob Campus among 217 third-, fourth-, and fifth-year undergraduate students. An online questionnaire with 10 questions was shared with the participants to assess their perceptions of research using a 5-point Likert scale. A proportionate stratified random sampling technique was employed, and IBM SPSS Statistics (Version 25) software was used in carrying out the data analysis.

Results

A total of 217 students invited to participate in the study, of whom 140 completed the questionnaire, corresponding to a response rate of approximately 65%. With regard to the compulsory nature of the research, 81(58%) students agreed that the research project should be compulsory. 88(63%) students thought it was important to do research in

undergraduate studies, whilst 20 (14%) of the students were neutral, and 32(23%) students disagreed that it is important to do research during undergraduate studies. Interest in doing research was greater with fifth-year students and lower with third-year students.

Conclusion

The study found that the majority of students thought research is important, but few students expressed interest in doing research, and the majority also regard it as stressful and time-consuming.

Keywords

Perceptions of research; undergraduate students; research

INTRODUCTION

Perception, in the broad sense, was defined as the ability to capture, process, and actively make sense of the information that our senses receive.¹ In this context, perception simply refers to the mental outlook that students have about research projects done in undergraduate studies. Students' perceptions can also simply refer to their thoughts, how they feel and what they believe about a certain thing or situation.²

Most universities have research as a compulsory module for undergraduate students in their curricula. It has been shown that research is essential for undergraduates in order to develop professionals who are scientifically oriented in their careers, since research is a fundamental way of discovering novel methods, techniques and approaches. But it seems that students' attitudes towards research are ambivalent, and the quality of the research studies carried out by undergraduate students needs to be considered.³

Research has many benefits for students; for example, it aids students in developing critical thinking skills as well as effective analytical and communication strategies that are paramount and globally in demand. Furthermore, research is needed for social and economic development and also for the formulation of policies.⁴

The medical school was established at the University of Namibia, and all students were required had to complete a research project as part of their undergraduate studies.⁵ Students learn better when they have positive perceptions of a subject, including research.² It is therefore essential to assess students' perceptions of research at the Hage Geingob Campus which will determine the level of commitment and quality of research projects done.

There are various studies focusing on undergraduate students' perceptions of research with conflicting results, as

Authors' Information

1. Andreas Shuuya Andreas, School of Medicine, Faculty of Health Sciences and Veterinary Medicine, University of Namibia, Windhoek, Namibia. (BChD). ORCID: 0009-00003-3613-369X
2. Silas Kudakwashe Bere, Department of oral Surgery, School of Dentistry, Faculty of Health Sciences and Veterinary Medicine, University of Namibia, Windhoek, Namibia. (BChD, MChD (OMFS), FAOCMF). ORCID: 0000-0002-6950-4245.
3. Rehema Tumaini Muro, Department of Community Dentistry and Orthodontics, School of Dentistry, Faculty of Health Sciences and Veterinary Medicine, University of Namibia, Windhoek, Namibia. (DDS, MPH, PD (Orthodontics)). ORCID: 0009-0005-6362-7841

Corresponding author

Name: Andreas Shuuya Andreas
Telephone Number: +264 81 754 6442
Address: Batch Street, Hage Geingob Campus, University of Namibia, Windhoek, Namibia
Email: address: andreandreas195@gmail.com
ORCID: 0009-00003-3613-369X

Authors' contributions

ORCIDIS and qualifications:

1. Andreas Andreas: Principal researcher – 40%, Article writing – 40%, Data collection – 60%, Data analysis – 40%
2. Silas Bere: Principal researcher – 30%, Article writing – 30%, Data collection – 20%, Data analysis – 20%
3. Rehema Muro: Principal researcher – 30%, Article writing – 30%, Data collection – 20%, Data analysis – 20%

shown in the following review of the literature. A prospective survey was conducted among dental students and interns at the College of Dentistry in the University of Dammam in Saudi Arabia to find out the perceptions and attitudes of students towards research. The survey found that senior students were more interested in research than junior students, yet in the end, only a few students partook in research projects since for them it was not compulsory.³

A cross-sectional study done among medical students at Shifa College of Medicine in Pakistan, to find out about the perceptions and attitudes of medical undergraduate students towards research, concluded that many students consider research as a useful subject in their careers and daily lives, but asserted that research is complex and stressful, and many are not willing to pursue a research career.⁶

Moreover, a 2018 meta-analysis aimed at understanding global perceptions of research among undergraduate medical students concluded that perceptions were similar worldwide. Medical students had positive attitudes towards research, and most of them were interested in research endeavours.⁷

Furthermore, another study was done among undergraduate pharmacy students at the University of Sydney in Australia using a questionnaire of 23 items examining the perceptions of pharmacy students towards research in general and their attitudes towards pharmacy practice research over a period of four years. The study found that the students perceived research to be a necessary component of their profession; however, many students did not have confidence in doing research, and few were looking forward to doing it. There were significant differences in perceptions of research in various years of study among pharmacy students.⁸

Lastly, a cross-sectional study conducted among undergraduate students at the American University of Beirut to assess their attitudes, perceptions, practices and barriers towards medical research. Students used in this study were from a variety of faculties, and a large sample was used. Results from the study showed that the majority of students had a positive attitude towards medical research, but they emphasised that a lack of mentoring and guidance is the main barrier to carrying out medical research. The strengths of this study is that it included students from almost all faculties, but it was mainly focused on the perceptions of medical research rather than research in general.⁹

Perceptions of research among undergraduates vary depending on the region in question; hence, perceptions of research among students from a variety of universities cannot be generalised to those of students at Hage Geingob Campus. Therefore, the objective of the study was to determine the perceptions of research among undergraduate students at Hage Geingob Campus in 2022 and to establish differences in perceptions of research between third-, fourth-, and fifth-year undergraduate students at Hage Geingob Campus.

METHODOLOGY

Research design and setting

A descriptive cross-sectional study was carried out at Hage Geingob Campus in 2022 to assess the perceptions of

research among third-, fourth-, and fifth-year undergraduate students.

Study population

The study recruited third-, fourth-, and fifth-year undergraduate students at Hage Geingob Campus from all faculties (i.e. medicine, pharmacy, dentistry, physiotherapy, occupational therapy and radiography) to assess their perceptions of research.

Sample and sampling method

The sample size was obtained using a simplified formula for proportions¹⁰ at 5% level of precision, 95% confidence interval, and a likely sample proportion of 50% and population size of 472. The formula is $n = N / (1 + N(e)^2)$, where n is the sample size, N is the population size, and e is the level of precision. The calculated sample size is 217. The stratum sample size was obtained with the following formula: $n_h = (N_h / N) * n$, where n_h = sample size for h^{th} stratum, N_h = population size for h^{th} stratum, N = size of entire population and n = size of entire sample.

A proportionate stratified systematic random sampling technique was employed by the study to ensure that the study is not selectively biased. Students were grouped into strata according to the year and course of study. The systematic random sampling method was used to select sampling units from each stratum. Only students with student numbers selected in each stratum were contacted to take part in the study.

Research Instrument/ data collection tool

A questionnaire with Likert scale questions was used to collect data about undergraduate students' perceptions of research, and also to concurrently collect their demographic data. A pilot test was conducted on 5% of the participants to validate the questionnaire. The questionnaire consisted of ten questions. These questions focused on students' perceptions regarding the importance of research, the obligatory nature of research projects, future benefits of research, wastage of time in research and psychological barriers in undertaking research projects.

Data collection procedure

The online questionnaire was loaded on Google Forms with 10 questions. The link to the questionnaire was shared with UNAM third-, fourth-, and fifth-year students who were selected from the sampling frame via the specific students' cell phone numbers on WhatsApp or email addresses. The message shared with the students with the link to the questionnaire also contained the information leaflet, which students read before clicking on the link to the online questionnaire. Data collection was carried out between the 26th of May and the 29th of July in 2022.

Data analysis

IBM SPSS Statistics (Version 25) software was used in carrying out the data analysis. The proportions of students who considered research important or unimportant were reported. The p-value threshold for statistical significance was set at 0.05. A Chi-square test of independence was done to assess if there is an association between the year of study of the students and the students' perceptions of research.

ETHICAL CONSIDERATIONS

The research study was approved by the Research Ethics Committee at UNAM. Ethical approval was also granted by the Ministry of Health in Namibia. In this research study, a comprehensive participant information leaflet was provided together with the link to the questionnaire and sent to the participants via email or WhatsApp message. After clicking on the link to the online questionnaire, the first screen had the consent form. Only participants who voluntarily clicked accept on the consent form were able to take part in the study.

RESULTS

A total of 217 students were contacted, of whom 140 (65%) completed the questionnaire. Third year students were 52(37%), fourth years were 63(45%), and fifth year students were 25(17%). Figure I and Table I show the responses to the eight aspects of perceptions of research investigated in the study.

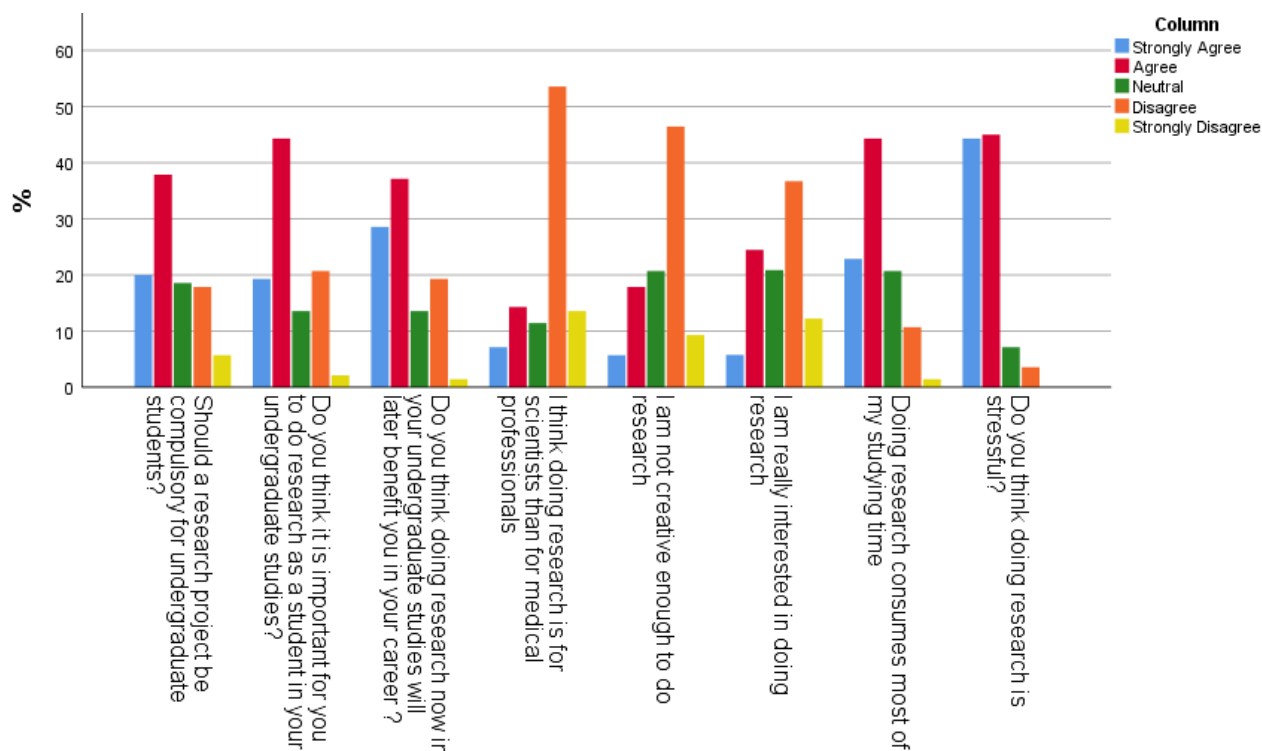


Figure I: Third, fourth and fifth year students' perceptions of research at Hage Geingob Campus

Table I: Perceptions of research among third-, fourth-, and fifth-year students

	Should a research project be compulsory for undergraduate students?	Do you think it is important for you to do research as a student in your undergraduate studies?	Do you think doing research now in your undergraduate studies will later benefit you in your career?	I think doing research is more for scientists than for medical professionals.
Strongly Agree	20.0%	19.3%	28.6%	7.1%
Agree	37.9%	44.3%	37.1%	14.3%
Neutral	18.6%	13.6%	13.6%	11.4%
Disagree	17.9%	20.7%	19.3%	53.6%
Strongly Disagree	5.7%	2.1%	1.4%	13.6%
	I am not creative enough to do research	I am really interested in doing research	Doing research consumes most of my studying time	Do you think doing research is stressful?
Strongly Agree	5.7%	5.8%	22.9%	44.3%
Agree	17.9%	24.5%	44.3%	45.0%
Neutral	20.7%	20.9%	20.7%	7.1%
Disagree	46.4%	36.7%	10.7%	3.6%
Strongly Disagree	9.3%	12.2%	1.4%	0.0%

With regard to the compulsory nature of the research, 81(58%) students agreed that the research project should be compulsory. 88(63%) students thought it was important to do research in undergraduate studies, whilst 20 (14%) of the students were neutral and 32(23%) students disagreed that it is important to do research during undergraduate studies. When participants were asked whether undergraduate research will have future career benefits, 92(66%) of the participants agreed that research done during undergraduate studies will later have benefits in future careers.

Furthermore, 95 (68%) students disagreed with the notion that research is for scientists rather than for medical professionals. However, 34 (24%) students regard themselves as not creative enough to do research and only 43(31%) students

reported to really have interest in doing research. 94 (67%) students reckon that doing research consumes most of their studying and 124(89%) students said research is stressful.

Perceptions of students with regard to year of study (Table II) were as follows: 33 (63%) third-year students thought it was important to do research in undergraduate studies, similarly 40(63%) fourth year students also said it is important to do research during undergraduate studies. 16(64%) fifth-years students agreed that undergraduate research is important. Moreover, Only 14 (27%) third-year students reported being interested in doing research, 19 (30%) fourth-year students reported that they were interested in research and 9 (36%) fifth-year students reported having interest in doing research.

Table II: Students' perceptions toward research by year of study (% , column-wise)

Variable	Response	Third Year (%)	Fourth Year (%)	Fifth Year (%)
Should a research project be compulsory for undergraduate students?	Strongly Agree	17.3	22.2	20.0
	Agree	40.4	38.1	32.0
	Neutral	19.2	14.3	28.0
	Disagree	17.3	20.6	12.0
	Strongly Disagree	5.8	4.8	8.0
Do you think it is important for you to do research as a student in your undergraduate studies?	Strongly Agree	17.3	23.8	12.0
	Agree	46.2	39.7	52.0
	Neutral	9.6	14.3	20.0
	Disagree	25.0	20.6	12.0
	Strongly Disagree	1.9	1.6	4.0
Do you think doing research now in your undergraduate studies will later benefit you in your career?	Strongly Agree	26.9	31.7	24.0
	Agree	42.3	33.3	36.0
	Neutral	9.6	12.7	24.0
	Disagree	21.2	20.6	12.0
	Strongly Disagree	0.0	1.6	4.0
I think doing research is for scientists than for medical professionals	Strongly Agree	5.8	9.5	4.0
	Agree	11.5	19.0	8.0
	Neutral	13.5	7.9	16.0
	Disagree	53.8	54.0	52.0
	Strongly Disagree	15.4	9.5	20.0
I am not creative enough to do research	Strongly Agree	3.8	4.8	12.0
	Agree	13.5	22.2	16.0
	Neutral	26.9	17.5	16.0
	Disagree	46.2	46.0	48.0
	Strongly Disagree	9.6	9.5	8.0
I am really interested in doing research	Strongly Agree	0.0	12.7	0.0
	Agree	27.5	17.5	36.0
	Neutral	29.4	17.5	12.0
	Disagree	35.3	41.3	28.0
	Strongly Disagree	7.8	11.1	24.0
Doing research consumes most of my studying time	Strongly Agree	19.2	25.4	24.0
	Agree	48.1	42.9	40.0
	Neutral	26.9	15.9	20.0
	Disagree	5.8	14.3	12.0
	Strongly Disagree	0.0	1.6	4.0
Do you think doing research is stressful?	Strongly Agree	48.1	42.9	40.0
	Agree	40.4	50.8	40.0
	Neutral	9.6	4.8	8.0
	Disagree	1.9	1.6	12.0
	Strongly Disagree	0.0	0.0	0.0

Chi-square test of independence was carried out to assess if there is a change in perceptions with change in year of study (Table III). Chi-square statistics was not significant for all variables except for interest in doing research, which was significant with significance level of 0.010. Interest in research was greater with fifth year students and lower with third year students. Overall proportion of students that think research is important in undergraduate studies is 0.58.

Table III: Chi-square test of independence assessing if there is a change in perceptions with change in years of study.

		Year of Study
Should a research project be compulsory for undergraduate students?	Chi-square	3.581
	Df	8
	Sig.	.893
Do you think it is important for you to do research as a student in your undergraduate studies?	Chi-square	5.408
	Df	8
	Sig.	.713
Do you think doing research now in your undergraduate studies will later benefit you in your career?	Chi-square	6.474
	Df	8
	Sig.	.594
I think doing research is for scientists than for medical professionals	Chi-square	5.929
	Df	8
	Sig.	.655
I am not creative enough to do research	Chi-square	5.058
	Df	8
	Sig.	.751
I am really interested in doing research	Chi-square	20.138
	Df	8
	Sig.	.010*
Doing research consumes most of my studying time	Chi-square	6.366
	Df	8
	Sig.	.606
Do you think doing research is stressful?	Chi-square	8.190
	Df	6
	Sig.	.225

* Statistically significant

DISCUSSION

This study reports the perceptions of research among third, fourth and fifth year undergraduate students at Hage Geingob Campus. The importance of this is that it helps in devising ways of eliminating limiting beliefs about research and hence allows students to approach undergraduate research with enthusiasm and innovation.

More than half of the students responded that undergraduate research should be compulsory. This is similar to the results of another study whereby 55.3% of students said research should be part of the undergraduate curriculum⁶. This could be explained by the perceived future career benefits of research foreseen by students, since 66% of the students

agreed that undergraduate research will later have benefits in future careers.

On the aspect that research is for scientists rather than for medical professionals, the majority of the students disagree, probably because they see how research is paramount in medicine and other related fields. However, it has been reported that the physician-scientist career is declining and there is a shortage of physician scientists which shows a decreasing interest in pursuing scientific research by medical professionals.⁷

Few students (less than one-quarter) regarded themselves as not creative enough to conduct research. The possible reason for this was not examined by the study, but other studies identified that students perceive themselves as having inadequate scientific writing skills and feelings of insecurity regarding data analysis in research.^{6,7} This may partly explain why some students perceived themselves as not being creative enough to conduct research.

The study showed that the majority of students reported not being interested in doing research, which is consistent with another study that found only 36% of students reported an interest in doing research.⁸ However, these findings contradict the results of the meta-analysis by Stone *et al.* which reported that medical students expressed a very high interest in research during their training.

The study found that interest in research differed by year of study, with the highest proportion among fifth-year students and the lowest among third-year students. of the student. This is consistent with the study's findings, which showed that 6th-year students and interns were more interested in research than junior students, as they realised the importance of research for their educational attainment. Another plausible reason why students develop more interest with increasing year of study could be that students become more involved in research and begin to have a greater understanding of research strategies and the acquisition of novel evidence obtained through research.³

The strengths of this study is that it involved students from all faculties and utilised a precise sampling method. A limitation of this study is that response bias may have affected the validity of the study since participants may withhold some information or endeavour to respond in a socially desirable manner. Another limitation of this study is the moderate response rate encountered in the data collection process, since only 65% of students took part in the study.

CONCLUSION

The study found that the majority of students thought research was important, but few expressed interest in doing research, and most also regarded it as stressful and time-consuming. Students should be appropriately engaged and mentored in research to develop a positive attitude towards it. Future studies should follow up a cohort of students from the third to the fifth year and assess their perceptions of research each year, as this will provide a more accurate picture of perceptions among university students.

CONFLICTS OF INTEREST

Authors declare no conflicts of interest.

FUNDING

None

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Mandibular interradicular bone mapping for safe Mini-implant placement in a South African sample

SADJ JULY 2026, Vol. 81 No.6 P391-P399

E Thomas,¹ AMP Harris²

ABSTRACT

Introduction

Mini-implants (MIs) provide reliable skeletal anchorage. Safe MI placement depends on sufficient interradicular bone clearance. Limited South African data exists to guide safe implant site selection.

Aim

To evaluate mandibular vestibular interradicular distances (IR) according to age, ancestry, sex, anatomical region, and vertical depth using CBCT scans, and identify safe sites for MI placement where IR exceeded 3.1 mm, a minimum threshold required for safety.

Design and Methods

A retrospective cross-sectional study was conducted using 78 CBCT scans of individuals >18 years. IR measurements were obtained at 3, 6, 9, and 12 mm apical to the mandibular alveolar crest. Data were stratified by sex, age group, ancestry, and region. Intra- and inter-rater reliability were assessed using intraclass correlation coefficients (ICC). Repeated measures regression analysis evaluated the effects of demographic and anatomical variables on IR.

Results

Measurement reliability was high (ICC = 0.98). Posterior mandibular regions demonstrated greater IR than anterior sites ($p < 0.001$). Greater IR values were observed in older individuals of African ancestry ($p = 0.019$) and increased with vertical depth in both sexes ($p < 0.001$). Bone map illustrated safe sites.

Conclusion

Anatomical and demographic factors influenced mandibular IR measurements. Bone mapping of safe MI sites is presented as a clinically useful guideline.

Keywords

Anchorage, Mini-implants, South Africans, interradicular distance, Mandible, Cone Beam Computed Tomography (CBCT), safe zones, bone map

INTRODUCTION

Achieving stable anchorage remains a fundamental challenge in orthodontic biomechanics, as unintended reactive forces can compromise treatment outcomes. Conventional anchorage strategies, including tooth-borne and extraoral appliances, are often limited by biomechanical inefficiency and dependence on patient compliance.¹ The concept of absolute anchorage, characterised by the complete elimination of unwanted reactive movements, represents an ideal but historically difficult to achieve treatment goal.

The introduction of temporary anchorage devices (TADs) has significantly advanced the field of biomechanics in orthodontics by introducing stable, skeletal-based anchorage systems that are independent of patient cooperation. Among these devices, mini-implants (MIs) have gained widespread clinical acceptance owing to their small dimensions, minimally invasive placement, ease of removal, and ability to provide reliable anchorage without reliance on teeth, extraoral appliances, or patient compliance.^{2,3} Case reports and clinical studies indicate that placement of MIs in the buccal interradicular bone is one of the most commonly adopted approaches to achieve skeletal anchorage.⁴

Anatomical sites where an MI may be placed with minimal risk of trauma to adjacent teeth and other vital anatomical structures are commonly referred to as 'safe zones'.⁵ These authors recommended that interradicular spaces should exceed 3.1 mm to be considered suitable for the placement of MIs with a diameter of 1.2 mm. Cone beam computed tomography (CBCT) has been used to measure interradicular spaces and to translate these measurements into clinically relevant 'safe zones'.⁶

In the mandible, 'safe zones' have been reported between the canine and first premolar, the first and second premolars, the second premolar and first molar, and the first and second molars.^{5,7} However, it remains unclear whether these proposed 'safe' MI sites are universally applicable across different population groups.

Given the reported anatomical variation between populations, the transferability of 'safe zones' identified in one population to other populations, including South Africans, remains uncertain. A survey conducted among South African orthodontists in 2016 reported that 67.9% of respondents experienced MI failure during treatment, while 22.2% refrained from using MIs due to concerns regarding complications.⁸

Authors' Information:

1. Dr Elizabeth Thomas. MDS, MSc(Dent), BDS. PhD Student, Department of Orthodontics, University of Western Cape. Email: lizathomas67@gmail.com. ORCID ID: 0000-0003-4351-2850
2. Prof Angela M.P Harris. PhD, FCD (SA) Orthodontics, MChD, Hons BSc (Epidemiology), BChD, Dipl Tertiary Education. Consultant and Supervisor, Emeritus Professor, Department of Orthodontics, University of Western Cape. Email: ampharris@uwc.ac.za ORCID ID: 0000-0001-6237-1200

Corresponding author:

Elizabeth Thomas
Email: lizathomas67@gmail.com

Author Contributions:

1. Dr Elizabeth Thomas – Role: Principal Researcher, data analysis, manuscript development and write-up
2. Prof Angela Harris – Role: Supervisor, Conception of study, manuscript development and editing

Despite this, locally relevant anatomical data for MI placement remain limited. This gap in evidence highlights the need for population-targeted research addressing factors influencing MI site safety and clinical success. Accordingly, the present study aimed to investigate potential safe MI placement sites within a South African sample and develop practical clinical guidelines through the generation of a mandibular bone map illustrating implant site suitability.

Therefore, the aims and objectives of this study were to evaluate mandibular vestibular interradicular distances (IR) according to age, ancestry, sex, anatomical region, and vertical depth in a South African sample using cone beam computed tomography (CBCT) scans, and to identify potential MI placement sites where interradicular clearance exceeded 3.1 mm, the minimum threshold required for safe placement of 1.2 mm diameter mini-implants.

METHODS AND MATERIALS

The CBCT scans used in this study were obtained from a stored research database at a teaching hospital in South Africa and consisted of retrospective scans acquired for diagnostic and treatment purposes. All scans were generated using a Plan Meca Pro Max CBCT 3D scanner with the following specifications: 90 kV, 11.2 mA, 0.2 mm or 0.4 mm voxel size and a maximum field of view of 230 (diameter) mm by 260 (height). The dataset included pre-existing demographic information, including age, sex, and ancestry, which had been recorded for previous research projects.^{9,10} The study was retrospective in nature, and scans were selected using a purposive convenience sampling method based on predefined inclusion and exclusion criteria.

Inclusion and exclusion criteria

To be eligible, the scans needed to fulfil the following conditions: 1) Scans that displayed clearly and completely the region of interest of this study, 2) Scans of individuals, male and female, from the South African population, > 18 years of age. Conversely, scans of subjects were excluded if they displayed the following: 1) evidence of any pathology, trauma, and periapical/ periodontal lesions 2) crowding (> 3-4 mm) or blocked out teeth 3) mandible with more than 3 teeth missing excluding the third molars 4) presence of large fillings or restorations that produced “scatter” and interfered with 3D analysis 5) scans of patients undergoing orthodontic treatment or intermaxillary fixation.

Sample Size

To assess the sample size required to address the key research question, namely the comparison of mean data at

a given measurement point to the cut-off value for safety, within each of the demographic groups, a sample size estimation was performed in G*Power.¹¹ For a one-sample t-test, the detection of a medium effect size, should it exist (Cohen’s d=0.5), a minimum sample size of 27 scans per demographic group is required.

Following strict application of the inclusion and exclusion criteria, the final sample consisted of 78 mandibular CBCT scans. Demographic variables included age (18–25 years and 26–52 years), sex (male and female), and ancestry, categorised as South Africans with African ancestry (SAA) and South Africans with European ancestry (SAE). The distribution of demographic characteristics is summarised in Table 1. The unequal subgroup distribution and overall sample size are to be noted as study limitations.

Table 1: Demographic data of the mandibular scans. (SAA = South Africans of African ancestry; SAE = South Africans of European ancestry)

Population group	SAA		SAE		Total
Sex	Female	Male	Female	Male	
Age group (years)					
18 - 25	9	13	11	6	39
26 - 52	18	14	5	2	39
Subtotal	27	27	16	8	
Total	54		24		78

Image processing and scan orientation

The CBCT scans were saved in Digital Imaging and Communications in Medicine (DICOM) files and analysed using Avizo v. 8.0.0 (Visualisation Sciences Group Inc., Bordeaux). All scans were reoriented using the cervical reference plane recommended by Theye *et al.*¹² Anatomical landmarks were positioned on the buccal surfaces along the cementoenamel junction (CEJ) of the first molars and the premolars in the three-dimensional virtual models. A best-fit plane was positioned through these selected landmarks and used to standardise mandibular orientation across all scans (Figure 1).

Slice extraction and landmark placement

Once the virtual object was reoriented, it was examined in the occlusal view to position three anatomical landmarks as seen in Figure 2. The first landmark represented the contact point between two adjacent teeth. The most apical point of

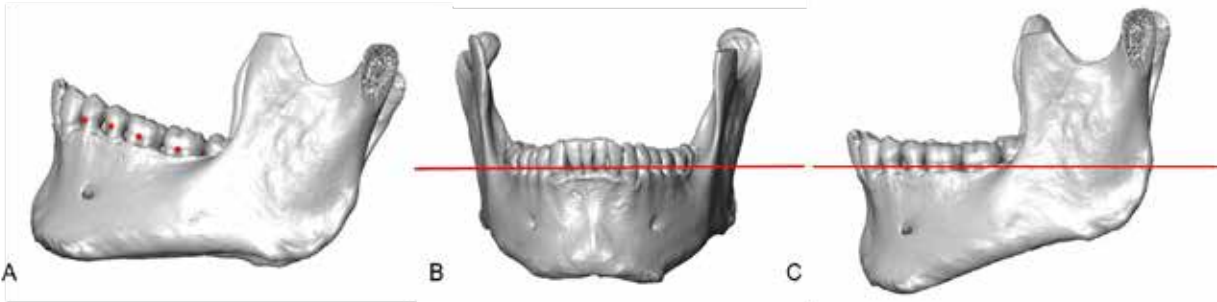


Figure 1: View of the virtual object with landmarks and best-fit alignment plane. A) Lateral view of the mandible with landmarks (in red) positioned at the level of the cementoenamel junction. B) Frontal view of the mandible with the best-fit plane going through the landmarks. C) Lateral view of the mandible after alignment to the best-fit plane.

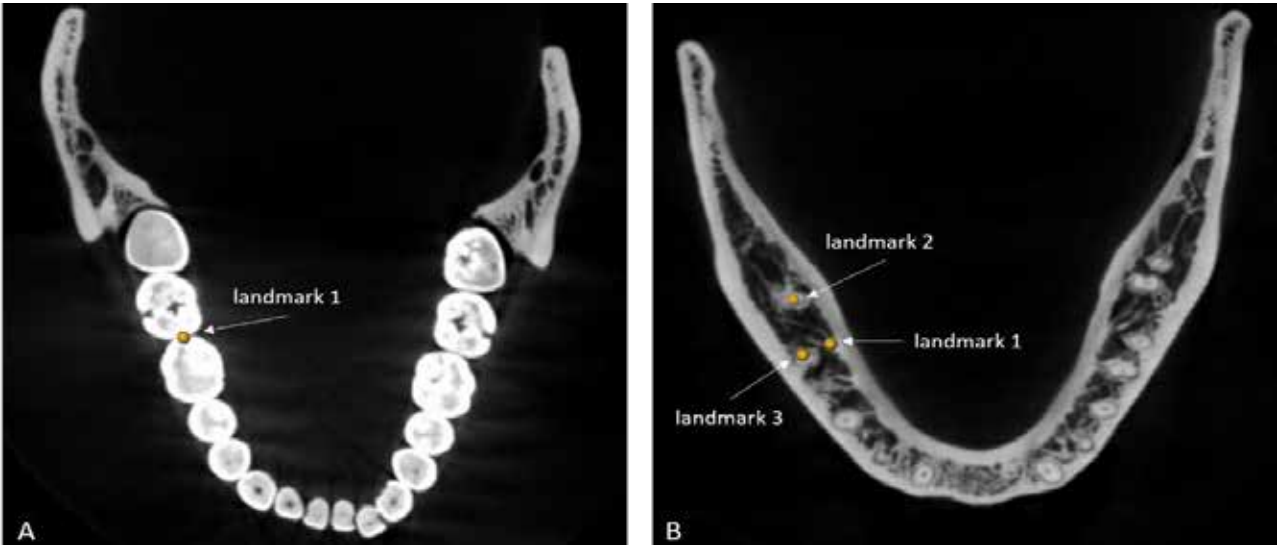


Figure 2: Sequential images depicting the steps involved in extracting a mesiodistal slice at each contact area using three landmarks. A) The first point of contact between adjacent teeth in the occlusal (top) view was named landmark 1. B) Translation of the slice apically to find the most apical point of the mesial root of the distal tooth (yellow sphere on top), named landmark 2, and the most apical point of the distal root of the mesial tooth (the yellow sphere on the bottom left), named as landmark 3. On the right is landmark 1 (contact point).

the mesial root of the distal tooth and the most apical point of the distal root of the mesial tooth of two adjacent teeth in an interdental contact area site were marked as landmarks 2 and 3, respectively (Figures 2A and 2B).

The virtual model was then oriented such that the three landmarks were aligned and landmark 1 was positioned centrally between landmarks 2 and 3. Subsequently, the mesiodistal virtual slice passing through all three landmarks was extracted and used to measure the inter-radicular distance between two adjacent teeth (Figure 3).

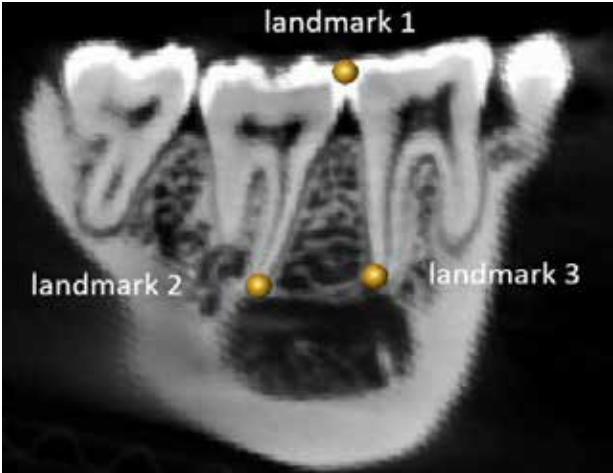


Figure 3: Slice with all three landmarks in the mesiodistal plane. This slice was extracted for inter-radicular distance (IR) measurements.

Interradicular distance measurement

Extracted slices were segmented to differentiate interradicular bone from the adjacent tooth roots. A custom Python-based algorithm was developed to automate interradicular measurements. The most superior bone pixel within the segmented region was defined as the alveolar crest tip. The program then proceeded to measure interradicular distances at 3 mm, 6 mm, 9 mm, and 12 mm apical to the crest by calculating the shortest orthogonal distances between opposing bone surfaces. Pixel measurements were converted to millimetres based on image resolution (Figures 4 and 5).



Figure 5: Image showing the segmented interdental bone in isolation with the measurement levels and values. The magenta lines on the white segmented bone show the measurement levels, and the script in green displays the measurement values at each level.

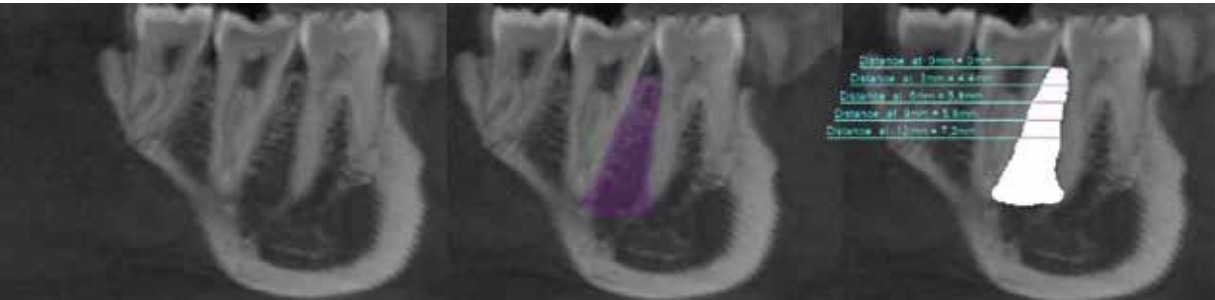


Figure 4: The sequence of inter-radicular distances (IR) slice creation. The images depict IR slices extracted from a scan. The centre image shows the segmentation process, while the right image displays the segmented bone (in white) superimposed on the slice. Linear measurements were taken at multiple levels, with the baseline passing through the most superior pixel of the alveolar bone.

Reliability assessment

All measurements were performed by the primary investigator. Intra-rater reliability was assessed by repeating 55 randomly selected inter-radicular measurements after a three-month interval. To assess inter-rater reliability, 48 inter-rater observations were generated for two observers (once each).

Safety threshold determination

Previous studies have reported that the minimum clearance required between mini-implants and adjacent roots ranges from 0.5 mm to 2.0 mm on either side of the implant.^{5,13–15} In addition, a periodontal ligament width of approximately 0.25 mm on each side was incorporated to minimise the risk of root contact. Accordingly, the minimum interradicular clearance required for placement of a 1.2 mm diameter mini-implant was calculated as follows: implant diameter (1.2 mm) + safety clearance (1.0 mm; 0.5 mm on each side) + periodontal ligament allowance (0.5 mm) = 2.7 mm. Therefore, an interradicular width of 3.1 mm was considered more than sufficient for safe placement of a 1.2 mm diameter mini-implant. Subsequently, the calculated safety threshold /interradicular clearance of 3.1mm was used to classify interradicular sites as safe or unsafe for mini-implant placement.

Methodology for Statistical Analysis:

The intra-rater and inter-rater reliability were determined by the Intra-Class Correlation Coefficient (ICC). The effect of anatomical and demographic variables on the outcome IR was assessed by repeated measures regression with the outcome as the dependent variable, and sex, age group, ancestry, region, and distance from alveolar crest as independent variables (together with their interactions), and patient as the repeated measure. Non-significant interactions were removed for model parsimony. Post-hoc tests were conducted using the Tukey-Kramer adjustment for unequal group sizes. The 95% confidence interval for the mean IR at each site- depth combination was compared to 3.1 mm, the safety threshold required for a small 1.2 mm diameter implant. Data analysis was carried out in Stata. A 5% significance level was used.

RESULTS

Reliability analysis

Intra-rater reliability for inter-radicular measurements was excellent, with an intraclass correlation coefficient (ICC) of 0.98 (95% CI: 0.96–0.99). Similarly, inter-rater reliability was high, with an ICC of 0.98 (95% CI: 0.97–0.99).

Effects of region, age, ancestry, sex, and distance (levels) on IR

The interactions between sex and region, ancestry and region, sex and ancestry, age and sex, age and region, ancestry and distance, and region and distance were not significant and were removed for model parsimony. The statistical model that remained for IR was in terms of age group, sex, ancestry, region and distance as main effects and the interaction effects between age and ancestry, sex and distance.

Thus, the repeated measures regression analysis demonstrated that only the main effect of region as a variable and the interaction effects between age-ancestry and sex-distance had a significant effect on the estimated mean of the IR in the mandible. Regionally, the mean IR for the right and left posterior mandibular regions recorded significantly higher values (both $p < 0.001$) than for the anterior region (Figure 6).

Examination of the age-ancestry group interaction utilising post-hoc tests showed that the mean IR was significantly higher for older individuals in the SAA group compared to older SAA individuals ($p = 0.019$). For the younger age group, the mean IR was not significantly different between the ancestral groups ($p = 0.69$). Within each ancestral group, there was no significant difference in mean IR between the old and the young sets ($p = 0.17$ and 0.10 for SAA and SAE, respectively). The results are also presented graphically (Figure 7).

For both sexes, the mean IR increased significantly with increasing distance from the alveolar crest across 3 mm, 6 mm, 9 mm and 12 mm measurement levels (all $p < 0.001$). For the 12 mm measurement level, mean IR was significantly higher for females ($p = 0.022$). The sex-distance interaction is illustrated (Figure 8).

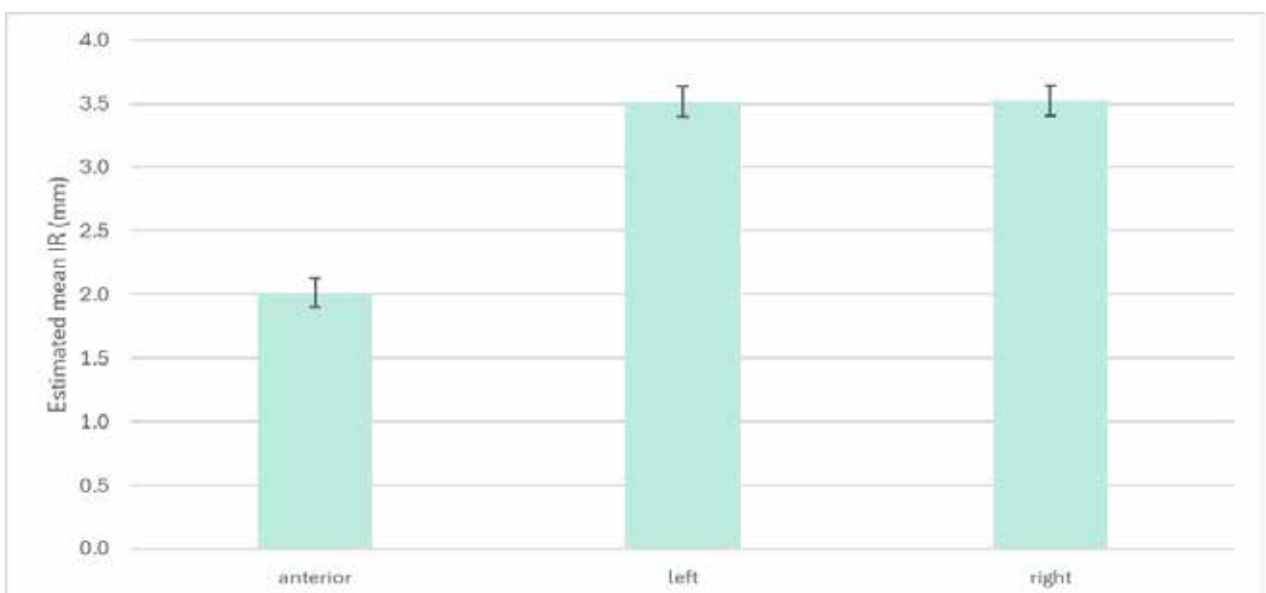


Figure 6: The main effect of region on the estimated mean interradicular distance for the three mandibular sextants based on repeated measures regression analyses. Error bars denote the 95% confidence interval for the mean. (IR = interradicular distance).

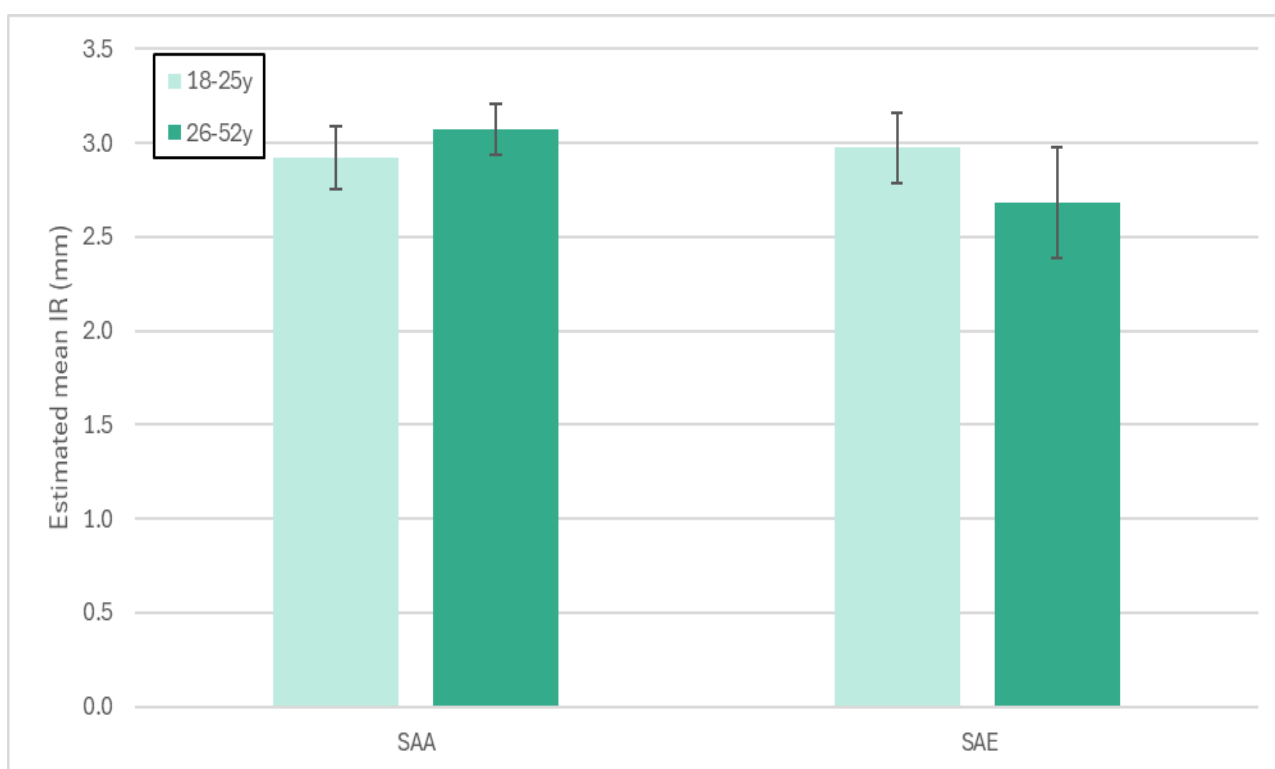


Figure 7: Illustration of the effects of age and ancestry groups on the estimated mean interradicular distance based on repeated measures regression analyses. Error bars denote the 95% confidence interval for the mean. (IR = interradicular distance; SAE = South African of European ancestry; SAA = South African of African ancestry)

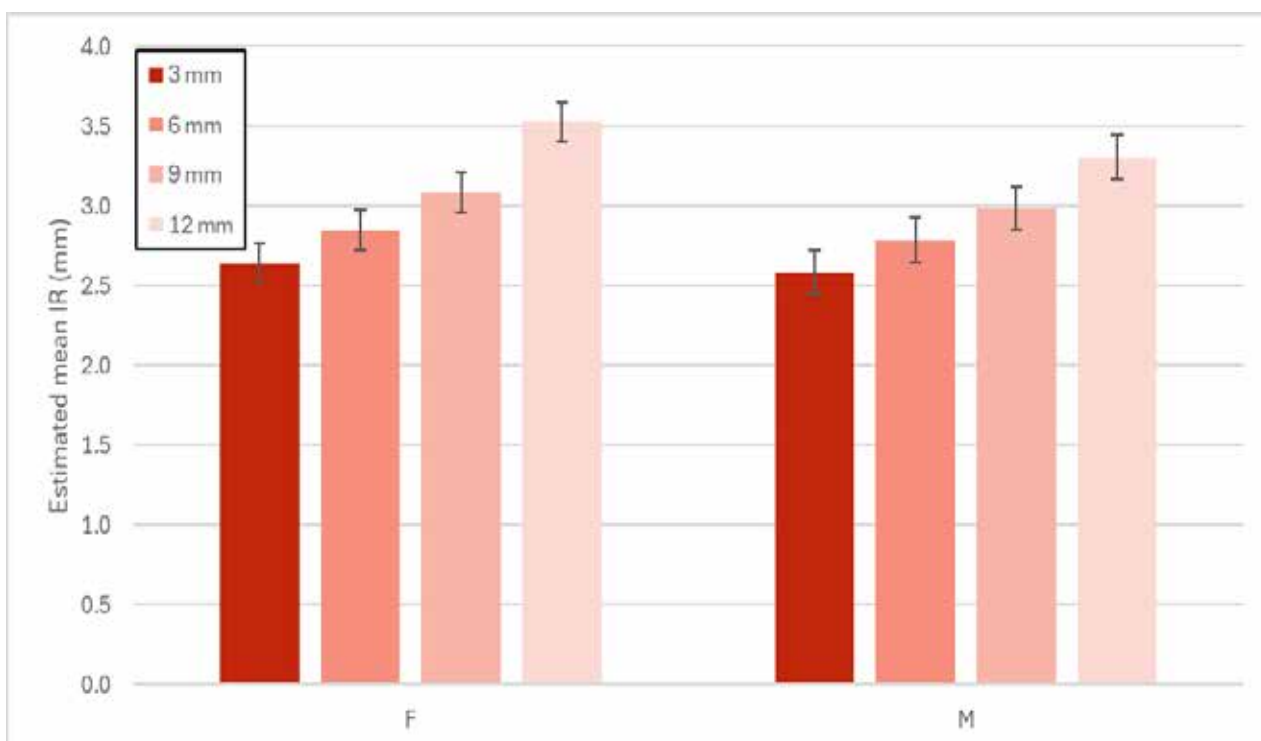


Figure 8: The effect of the sex-distance interaction on the mean interradicular distance of the mandible based on repeated measures regression analyses. Error bars denote the 95% confidence interval for the mean. (IR = interradicular distance; F = Female; M = Male)

Identification of safe interradicular sites and bone map generation

To identify clinically safe placement sites, the 95% confidence intervals of the mean interradicular distances at each site-depth combination were compared with the predefined safety threshold of 3.1 mm. Sites with mean inter-radicular distances exceeding this threshold were classified as safe for placement of 1.2 mm diameter mini-implants (Table 2).

IR		Distance from alveolar crest														
Region	3mm				6mm				9mm				12mm			
Left	n	Mean	95% CI		n	Mean	95% CI		n	Mean	95% CI		n	Mean	95% CI	
38-37	45	3.24	2.89	3.59	45	3.84	3.48	4.21	45	4.43	3.98	4.88	44	5.9	5.2	6.59
37-36	74	3.37	3.19	3.56	75	3.62	3.4	3.83	75	3.83	3.57	4.09	74	4.44	4.11	4.76
36-35	77	3.15	3	3.31	77	3.31	3.12	3.51	77	3.49	3.24	3.73	77	3.92	3.61	4.24
35-34	76	3.16	3.02	3.31	76	3.47	3.3	3.63	76	3.74	3.55	3.94	76	4.02	3.74	4.3
34-33	75	2.51	2.35	2.67	75	2.63	2.44	2.81	75	2.74	2.52	2.96	75	2.99	2.73	3.24
Anterior																
33-32	78	1.91	1.8	2.03	78	2.16	2.02	2.3	78	2.39	2.23	2.54	78	2.78	2.58	2.99
32-31	78	1.64	1.54	1.75	78	1.69	1.57	1.81	78	1.81	1.68	1.95	77	1.92	1.76	2.08
31-41	77	1.64	1.53	1.76	77	1.76	1.63	1.89	77	1.81	1.7	1.93	76	2.03	1.89	2.17
41-42	78	1.6	1.52	1.68	78	1.6	1.5	1.69	78	1.71	1.61	1.81	78	1.86	1.73	1.99
42-43	78	2.14	2.02	2.27	78	2.33	2.17	2.48	78	2.61	2.44	2.78	78	2.87	2.64	3.1
Right																
43-44	76	2.54	2.39	2.7	76	2.7	2.52	2.89	76	2.87	2.65	3.08	76	3.15	2.92	3.39
44-45	76	2.98	2.81	3.14	76	3.36	3.16	3.55	76	3.69	3.46	3.91	76	4.10	3.81	4.39
45-46	77	2.97	2.79	3.14	76	3.15	2.94	3.36	76	3.35	3.11	3.59	76	3.70	3.4	4
46-47	72	3.57	3.38	3.76	72	3.78	3.56	4	72	3.94	3.66	4.22	70	4.39	4.03	4.76
47-48	44	3.63	3.28	3.99	44	4.05	3.51	4.59	43	4.72	4.07	5.36	40	5.92	5.09	6.75

mean IR significantly <3.1mm

mean IR significantly >3.1mm

Table 2: Interradicular distances: regional mean measurements at distances (levels) 3, 6, 9, 12 mm from the alveolar crest of the mandible. IR = Interradicular distance, n = number of observations, tooth notation: 38-37 = interdental site between the left third molar and left second molar, up to 47-48 = right third molar and right second molar.

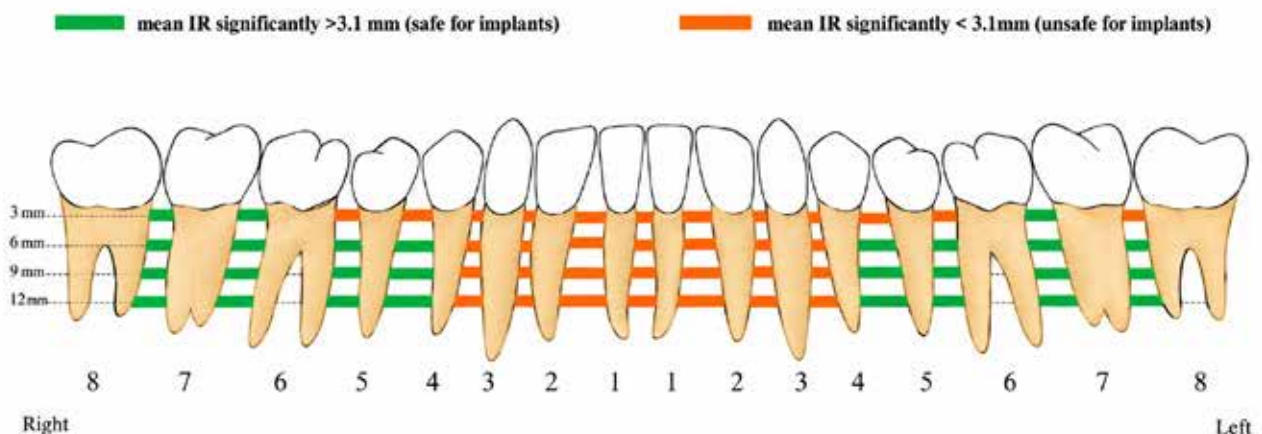


Figure 9: Illustration of unsafe, safe sites based on mean IR values for the mandible of the study sample. The teeth are numbered starting from the distal aspect of one side of the arch to the midline or centre, with number 8 corresponding to the third molar and number 1 corresponding to the central incisor of that particular side.

Using these measurements, a visual mandibular bone map was generated to illustrate site-specific safe and unsafe zones for orthodontic mini-implant placement (Figure 9).

DISCUSSION

Several factors influence the amount of interdental space available at each interdental site of the mandible. These include the anteroposterior position of the interdental site along the mandibular arch, the vertical distance from the alveolar crest to the basal region of the mandible,¹⁶ tooth dimensions across population groups, dental alignment,^{17,18}

sagittal skeletal relationships,¹⁹ and root morphology.²⁰ Understanding these variations in interdental spacing is vital for optimal MI placement and orthodontic treatment planning. Regionally, the anteroposterior gradient in IR observed in the present study was similar to previous studies demonstrating an increase in interradian distances along the anteroposterior axis.²⁰⁻²² This trend is anatomically plausible, as anterior teeth are smaller and require less space, whereas posterior teeth are wider mesiodistally, possess broader occlusal tables, and are associated with increased mandibular arch width in the posterior regions.²³

The posterior predominance of safe MI sites observed in the bone map may be attributed at least in part to the anteroposterior increase in IR observed in the present study.

Furthermore, in the posterior regions from the mesial to the distal aspect, roots of adjacent teeth tend to diverge distally towards the apical end, thereby offering increased interradicular clearance.²⁴ As a result, anatomically, more room is available at increased depths for MI placement. This explanation has also been elaborated upon in the literature.^{15,25} In the present study, the number of compliant sites for the safety criteria-IR >3.1 mm increased in all regions for both males and females as the vertical distance increased from the tip of the alveolar crest toward the mandibular base. The increase in posterior safe sites with greater vertical depth has also been corroborated in the literature.¹⁶ This may reflect the greater interradicular width available between adjacent teeth due to the gradual apical narrowing of roots.

Generally, as the depth increases, the IR increases,²⁶ enhancing the suitability of a site from a hard tissue perspective. However, this benefit is counterbalanced by the tendency of the screw head to be placed in a zone of non-keratinised or movable gingiva; a soft tissue environment that is associated with an increased risk of inflammation, peri-implantitis and patient discomfort. This creates a clinical trade-off between favourable hard tissue characteristics and less desirable soft tissue conditions, as well as an increased risk of iatrogenic injury at greater insertion depths. Therefore, mini-implants are ideally inserted near the mucogingival junction, corresponding to approximately 4 mm within the attached gingival zone, to minimise mucosal irritation.^{27,28} Alternatively, the clinician should allow the mucosa to cover the MI head completely while allowing only a wire or an attachment to pass through the mucosa.²⁹

Studies have demonstrated that a definite link between sex and stature exists as predictors of tooth size and jaw dimensions.²³ Thus, jaw and tooth dimensions are bigger in the male population than in the female population group. The increased interradicular distance at the 12 mm measurement level observed in the female population of this sample may be due to the slender morphology of female tooth roots toward the apex and probably represents an expression of sexual dimorphism in root morphology.

A possible explanation for the significantly higher IR values observed in the older SAA group compared to the older SAE group may relate to ancestry-related craniofacial characteristics. Individuals of SAA have been reported to exhibit well-developed jaws, a lower prevalence of malocclusion, and a tendency towards bimaxillary protrusion compared to their SAE counterparts.³⁰ Furthermore, bimaxillary protrusion in SAA has often been associated with a mild to moderate skeletal Class III pattern.³¹ Skeletal Class III relationships are generally characterised by increased mandibular lengths, greater posterior arch lengths, and larger gonial angles when compared to Class I and Class II skeletal types.^{32,33} It is therefore plausible that subjects in the older SAA group within the present sample exhibited mandibular characteristics consistent with a Class III skeletal pattern, contributing to increased mandibular dimensions and, consequently, greater inter-radicular distances.

In addition to ancestry-related skeletal characteristics, age appears to further influence IR values. A local study reported

that ancestry-related differences in craniofacial dimensions become more pronounced with increasing age.³³ Consistent with this, the present findings suggest that variations in IR are influenced by age and may result in a greater number of potential safe sites in older participants. These findings are in agreement with those of Ludwig *et al* (2011), who reported that older individuals tend to exhibit inter-radicular areas with more favourable dimensions for mini-implant placement compared with younger cohorts.¹⁵

Many published studies in the literature investigating mandibular interradicular implant sites have concentrated only on the posterior regions of the mandible and evaluated only one side of the mandibular jaw or pooled the data from the right and left sides, assuming bilateral symmetry.^{34–36} In contrast, the present study examined interdental areas in the anterior and posterior regions and found distinct regional differences in IR values between the right, left and anterior regions. By adopting this approach, a comprehensive dataset for the entire jaw was created and, in turn, helped to generate a site-depth detailed bone map that reflected the anatomical variability in IR across the entire mandible.

From a clinical perspective, the bone map facilitates the translation of measured interradicular measurements into clearly demarcated safe and unsafe zones for MI placement. In the present study, a minimum inter-radicular clearance of 3.1 mm, corresponding to a 1.2 mm diameter mini-implant, was applied as a conservative safety criterion or threshold to minimise the risk of root proximity and iatrogenic injury. Application of this safety threshold revealed distinct regional patterns of safe and unsafe implant sites.

The bone map demonstrated a greater concentration of safe sites in the posterior mandibular regions, particularly at increased vertical depths from the alveolar crest. The distributions seen in the present study closely mirror the anteroposterior and vertical increase in inter-radicular distances described earlier. The increase in the number of safe sites as the vertical distance from the alveolar crest increased was similar to the findings of previous studies.^{28,37} The maximum number of sites was found in the interdental areas between the molars, followed by the interdental area between the premolars.

When bilateral data were combined, eight safe sites were found between the first and second molars, seven sites between the second and third molars, six sites between the first molar and second premolar, and six sites between the premolars. While previous studies have reported greater interradicular availability in posterior regions distal to the first premolar,^{5,37–39} the relatively high number of safe sites identified between the second and third molars when compared to the first molar -pre-molar region or the premolar region represents a noteworthy finding in the present study. The finding may be attributed to several contributing factors. Anatomically, the posterior mandibular region demonstrates increased arch width and greater apical root divergence, which can result in wider interradicular spaces at deeper measurement levels. In addition, third molars often exhibit greater positional variability,⁴⁰ including distal angulation and increased separation from the second molar roots, which may further contribute to increased available interradicular clearance in this region. Methodologically, many previous studies that explored safe interradicular sites^{18,27,37} have excluded third molar regions or limited their analysis to the

premolar, second premolar and first molar, and lastly, first and second molar regions, which may partly account for the lower representation of this area in published literature. Finally, ancestry-related craniofacial characteristics within the present South African sample may also have influenced posterior mandibular dimensions, contributing to the observed distribution of safe sites.

Conversely, the entire anterior mandibular region exhibited unsafe zones, reflecting the narrower inter-radicular spaces in the anterior segment and the more parallel root morphology of anterior teeth. These findings reinforce the anatomical limitations of the anterior mandible for MI placement in this population sample when a stringent safety criterion was applied.

Importantly, the bone map integrates anatomical IR variation with a clinically relevant safety threshold, providing an evidence-based visual guide for selecting favourable vestibular mini-implant insertion sites in the mandible. Although individual anatomical variation remains inevitable, the present data provide a robust guideline for initial site selection, with final confirmation to be undertaken on a patient-specific basis using appropriate radiographic assessment.

CONCLUSION

Based on the applied safety criterion of a minimum inter-radicular clearance of 3.1 mm, the following regions were identified as favourable for orthodontic mini-implant placement despite the study's limitations:

Posterior right mandibular region:

- Levels 3, 6, 9, and 12 mm between the right third and second molars, and between the right second and first molars
- Levels 6, 9, and 12 mm between the right first molar and second premolar, and between the first and second premolars

Posterior left mandibular region:

- Levels 6, 9, and 12 mm between the first and second premolars, between the second premolar and first molar, and between the left second and third molars
- Levels 3, 6, 9, and 12 mm between the left first and second molars

The variation in inter-radicular dimensions highlights the importance of considering anatomical region, vertical depth, age, ancestry, and sex when planning safe orthodontic mini-implant placement, despite the limitation of the study sample size.

By providing comprehensive hard tissue site-specific information at a glance, this study addresses an important gap in locally relevant data and reduces uncertainty associated with MI site selection. These findings are expected to support wider clinical adoption of MIs, expand non-surgical orthodontic treatment options, and ultimately contribute to improved patient care within the South African context.

Future Recommendations

It is hoped that future studies will explore the main demographic population groups in South Africa using larger, more representative samples to derive guidelines specific to each ancestry-related population group.

ETHICAL CONSIDERATIONS

Ethical approval has been obtained from the Biomedical Research Ethics Committee, of the concerned University for this research project (Ethics clearance number: BM21/9/10), indicating compliance with ethical standards in this research.

FUNDING

The study was partially funded by the South African Society of Orthodontists (SASO).

CONFLICT OF INTEREST

None.

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Smile attractiveness and dental aesthetics: psychological and clinical implications for dental practice

SADJ JULY 2026, Vol. 81 No.6 P400-P403

G Streit,¹ Q Wessels,² GD Buchanan,³ J Smith,⁴ K Smith⁵

ABSTRACT

Introduction

Dental aesthetics influences perceived attractiveness, self-esteem and social judgement.

Aims and Objectives

To review the psychological and clinical evidence on how smile characteristics influence attractiveness and how this informs dental treatment planning.

Design

Narrative literature review.

Methods

English-language literature indexed in EBSCOhost was searched using terms related to dental aesthetics, smile attractiveness, proportional smile design and Digital Smile Design. The cited publications spanned 1978–2024 and included both contemporary and foundational literature.

Results

Tooth alignment, symmetry, size, colour, incisal display, gingival display, smile arc and lip position consistently

influenced perceived smile attractiveness. Proportional concepts such as the golden proportion, recurring esthetic dental (RED) proportion and golden percentage can aid smile analysis, but no single formula is universally applicable. Digital Smile Design improves diagnosis, communication and treatment predictability.

Conclusions

Dental aesthetics has important psychosocial consequences and should be managed through evidence-based, individualised planning rather than rigid aesthetic formulas.

Keywords

dental aesthetics; smile attractiveness; psychosocial impact; smile design; proportional analysis; Digital Smile Design

INTRODUCTION

Smile attractiveness is not determined by a single tooth measurement but by the interaction of dentolabial and facial variables. Improved dental appearance has been associated with better self-esteem, oral-health-related quality of life and social confidence.^{1,2} Perception of an attractive smile is influenced by tooth alignment, symmetry, tooth size, tooth colour, incisal display, gingival display, smile arc and upper lip position relative to the maxillary incisal edges.^{3–5} Adolescents with pleasing dental aesthetics are judged more favourably in domains such as leadership and social ability, while visible dental irregularities may negatively affect interpersonal appraisal.^{6–9} Because these judgements may influence psychosocial wellbeing and treatment demand, dental aesthetics should be approached as a clinical issue with psychological implications rather than as a purely cosmetic concern.^{10–15}

Within dentistry, this means that smile design should be guided by evidence-based analysis rather than by generalised beauty theory. A review that remains focused on dental aesthetics is therefore more useful clinically than a broad discussion of beauty in philosophy, sociology or neuroscience. The present paper examines the specific ways in which smile variables influence attractiveness and how these findings can inform contemporary dental treatment planning.

Aim

The aim of this article is to review the psychological and clinical evidence on dental aesthetics, with specific emphasis on smile attractiveness and its relevance to contemporary dental practice. The objectives are to identify the principal smile variables associated with perceived attractiveness, to evaluate the usefulness and limitations of proportional smile design concepts, and to consider how digital planning tools can improve communication and predictability in aesthetic treatment.

Authors' information

1. Dr. Günther Streit: BChD (Pret), MSc (Dent) (UWC), PG Dip Aesthetics (Pret), PDD Interceptive Orthodontics (UWC), PG Dip Practice Management (Pret), PG Dip Paedodontics (Pret), PG Dip Prosthodontics (Pret), PG Dip Endodontics (Pret), University of Namibia, Faculty of Health Sciences and Veterinary Medicine, Department of Anatomy. ORCID: 0000-0003-2251-7169
2. Prof. Quenton Wessels (University of Namibia, School of Medicine, Department of Human, Biological and Translational Medical Sciences, Unit of Anatomy), PhD (Anatomy), PhD (HSE), FHEA. ORCID: 0000-0001-8539-5459
3. Prof. Glynn D Buchanan: BChD, PDD (Endo), MSc (Dent), Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa. ORCID: 0000-0003-2957-166X
4. Dr Janis Smith: BChD, PDD (Endo), University of Pretoria, Private Practice.
5. Dr Karin Smith, Psychologist, D.Ed, Rand Afrikaans University, Private Practice.

The authors have no conflict of interest to declare

Corresponding author

Name: Dr Günther Streit
Email: coastal.dental.clinic@gmail.com
Mobile number: +264 81 241 9399

Responsibilities of the authors

1. The responsibility of Dr Günther Streit was to contribute to the scientific writing and proofreading of the manuscript. 40%
2. The responsibility of Prof Quenton Wessels was to contribute to the scientific writing, artwork and proofreading of the manuscript. 15%
3. The responsibility of Prof Glynn Buchanan was to contribute to the scientific writing and proofreading of the manuscript. 15%
4. The responsibility of Dr Janis Smith was to contribute to the scientific writing and proofreading of the manuscript. 15%
5. The responsibility of Dr Karin Smith was to contribute to the scientific writing and proofreading of the manuscript. 15%

Methodology

A narrative literature review was undertaken using an electronic search of EBSCOhost. Search terms included “dental aesthetics”, “smile attractiveness”, “smile design”, “golden proportion”, “golden percentage”, “RED proportion”, “Digital Smile Design”, “psychosocial impact”, and “dentofacial aesthetics”. English-language publications with clear relevance to dentistry, orthodontics, prosthodontics and aesthetic treatment planning were prioritised. The 42 publications cited in this review were published between 1978 and 2024. Selected foundational papers were retained for their continuing relevance to smile analysis and aesthetic treatment planning.

This review was narrative rather than systematic. The purpose was to synthesise clinically relevant evidence for dental practice, not to perform a formal meta-analysis. The discussion therefore emphasises concepts that recur across the literature and that have direct value in smile analysis, patient communication and treatment planning.

RESULTS

Four consistent themes emerged from the literature. First, dental appearance has measurable psychosocial effects and influences self-perception, quality of life and social confidence. Second, observer judgements of attractiveness are strongly affected by tooth alignment, symmetry, size, colour, gingival display, smile arc and lip dynamics. Third, proportional theories such as the golden proportion, recurring esthetic dental (RED) proportion and golden percentage may assist analysis, but none should be applied as a universal rule. Fourth, digital planning systems such as Digital Smile Design have strengthened diagnosis, interdisciplinary communication and treatment predictability.

Psychological and social significance of dental aesthetics

Dental appearance influences both self-evaluation and how patients are judged by others. Malocclusion, spacing, discolouration and altered gingival display have been associated with lower self-confidence and reduced oral-health-related quality of life.^{10,12-15} The psychosocial effects of dental appearance are clinically relevant because dissatisfaction with a smile may affect willingness to smile, social participation and treatment-seeking behaviour.^{1,2,12,13} Orthodontic and restorative treatment can improve psychosocial wellbeing, particularly when patients perceive that treatment has enhanced smile attractiveness and social confidence.^{14,15}

Observer-based studies also show that dental aesthetics affects interpersonal appraisal. Well-aligned teeth are associated with greater friendliness, competence and intelligence, while visible dental irregularities may adversely influence social judgements.⁶⁻⁹ Employment-related perceptions may also be affected, with attractive dental appearance contributing to more favourable evaluations in social and professional contexts.¹¹ Excessive gingival display, asymmetrical gingival margins and disharmonious tooth proportions can further reduce ratings of attractiveness and trustworthiness.¹⁶ These findings help explain why patients often present with concerns that are both functional and psychosocial, and they reinforce the need for clinicians to understand smile attractiveness as part of comprehensive patient care.



Figure 1. Frontal facial portrait illustrating facial form and lip contour. The image provides facial context and does not demonstrate tooth proportions, gingival display or smile arc.

Clinical determinants of smile attractiveness

Smile aesthetics depends on harmonious integration of the teeth, gingiva, lips and face. The frontal portrait in Figure 1 illustrates the broader facial context of dental aesthetic assessment.

Common determinants include tooth alignment, symmetry, size, shape, colour, width-to-length ratio, axial inclination, incisal embrasures, gingival margin levels, buccal corridor display and the relationship between the incisal plane and lower lip curvature.^{3,5,17-21} No single factor acts in isolation. Instead, attractiveness reflects the balance between individual components and the way they are perceived during speech and smiling.

The smile arc remains one of the most important clinical variables. A consonant smile arc, in which the curvature of the maxillary incisal edges parallels the contour of the lower lip, is generally considered more youthful and attractive than a flat smile arc.¹⁷⁻¹⁹ Incisor position and incisal display are therefore central to smile planning. The clinician must also evaluate gingival aesthetics, including the level and symmetry of the gingival margins, the extent of gingival exposure during smiling, and the effect of crown length on apparent tooth proportions.^{16,18,19}

Transverse and posterior features also contribute to the final appearance of the smile. Relationships between maxillary arch width, mouth width and facial width influence how full or constricted the smile appears.²⁰ The buccolingual inclination of canines and premolars affects the continuity of the visible arch and can alter perceived smile fullness.²¹ These findings confirm that smile analysis should extend beyond the maxillary central incisors to include the wider dentolabial and facial context.

Tooth colour should be considered alongside form and position. Patients frequently interpret a harmonious smile as one in which shade, value and surface texture appear natural and consistent with age and facial appearance. Excessively

dark, opaque or mismatched teeth may detract from smile attractiveness even when alignment is ideal, while very white restorations can appear artificial if they are not integrated with lip dynamics, gingival display and facial complexion.^{4,5,19} Clinicians should therefore assess colour as part of a broader composition that includes tooth form, gingival health and the visibility of teeth during speech and smiling.

Lip position should also be defined clearly in clinical terms. In smile analysis it refers to the relationship of the upper lip to the maxillary incisal edges and gingival margins at rest, during speech and in a full smile. This relationship determines how much tooth and gingiva are displayed and whether the smile is perceived as youthful, restrained or gummy.¹⁷⁻¹⁹ Because lip posture and mobility vary widely between patients, static measurements alone are insufficient. Aesthetic analysis should therefore include dynamic observation, photographs and, where appropriate, video records.

Proportional concepts in smile design

Several proportional theories have been proposed to guide smile design. Levin popularised the golden proportion for the visible widths of the maxillary anterior teeth. Ward later described the recurring esthetic dental (RED) proportion, and Snow proposed the golden percentage as a clinically practical alternative.²²⁻²⁴ These systems are attractive because they offer measurable frameworks for treatment planning, diagnostic wax-ups and restorative communication. However, naturally attractive smiles do not consistently demonstrate the classic golden proportion, and rigid application of any single formula may not suit individual patients.^{25,26}

Current evidence suggests that proportion should be used as a guide rather than as a rule. Studies indicate that dentists often prefer central incisor width-to-length ratios of approximately 75% to 85% and lateral-to-central incisor width relationships within broad aesthetic ranges rather than according to one mathematically fixed standard.^{27,28} Similarly, a maxillary lateral incisor approximately 1 to 1.5 mm shorter than the central incisor is often judged most attractive.²⁹ The clinical lesson is that proportion must be interpreted in relation to face shape, sex, age, ethnic background, lip dynamics and the patient's own expectations.^{25,26,30}

In practical terms, proportional analysis can be simplified. The clinician should first assess the central incisors in relation to the face and upper lip, then compare the visible widths and lengths of the lateral incisors and canines, and finally confirm that anterior proportions remain compatible with gingival levels, smile arc and midline position. This approach preserves the value of mathematical guidance while avoiding overreliance on idealised numbers.²³⁻³⁰

A useful clinical sequence is to begin with the central incisors, because they dominate frontal smile display. Their visible width, length, incisal edge position and gingival levels should first be established. Lateral incisors can then be assessed relative to the centrals, followed by the canines. At this stage the clinician should determine whether the apparent relationships are harmonious, whether restorative or orthodontic correction is required, and whether alterations in tooth form will remain consistent with the lower lip, facial midline and gingival contour. This type of structured assessment is more clinically reliable than forcing the case to conform to one theoretical ratio.

Digital Smile Design in contemporary practice

Digital Smile Design (DSD) has become an important adjunct in aesthetic dentistry because it allows analysis, simulation and communication before irreversible procedures are undertaken.³¹⁻³⁴ By integrating facial photographs, videos, intra-oral images, digital casts and restorative plans, DSD enables more systematic evaluation of facial symmetry, incisal display, tooth proportions, gingival architecture and smile line.³¹⁻³³ It also provides a visual framework for discussing treatment limitations, staging and likely outcomes with patients.

The value of DSD lies not in creating a uniform smile template, but in individualising treatment. Digital planning assists interdisciplinary communication among restorative dentists, orthodontists, periodontists and laboratory technicians, and it may improve case acceptance by helping patients visualise proposed changes before treatment begins.³¹⁻³⁵ When combined with conventional clinical examination, DSD supports a more predictable and conservative approach to treatment planning, particularly in cases involving aesthetic rehabilitation, interdisciplinary care or complex smile asymmetries.

DSD is especially useful in cases where the patient struggles to verbalise aesthetic concerns or where different disciplines must coordinate treatment. By mapping the facial midline, occlusal cant, incisal plane, gingival architecture and proposed tooth forms, the digital workflow makes asymmetries and disharmonies easier to explain and document. It can also support mock-ups and provisional restorations, allowing aesthetic and functional changes to be assessed before definitive treatment is completed.³¹⁻³⁴ In this sense, DSD does not replace clinical judgement; rather, it makes that judgement more transparent and communicable.

Smile line, arch form and the visible dentition

Although the anterior teeth dominate smile assessment, the rest of the visible arch also contributes to attractiveness. Posterior teeth should create a progressive transition from canine to premolar display without abrupt changes in width, inclination or occlusal plane. Rather than applying a strict posterior golden ratio, clinicians should aim for a continuous arch form that supports symmetry, consonant smile arc and natural buccal corridor display.^{18-21,36-38}

The smile line is determined by the relationship between upper lip position and maxillary incisal display. Ideally, the incisal edges of the maxillary anterior teeth follow the curvature of the lower lip, with harmonious gingival exposure and coincident or minimally deviated dental midlines.^{17-19,37,38} First premolars should contribute naturally to the visible arch without appearing too upright, constricted or over-dominant, while molars should support overall balance without interrupting the curvature of the smile. These relationships must be assessed dynamically, as lip mobility during smiling can substantially change incisal and gingival display.

Function remains fundamental. Aesthetic changes should not compromise occlusion, anterior guidance, periodontal health or long-term stability.³⁵⁻³⁸ The challenge in contemporary smile design is therefore to integrate aesthetic composition with biological soundness and durable function.

Clinical implications for practice

The literature supports a patient-centred model of aesthetic dentistry. Patients increasingly expect treatment that restores function while also improving smile appearance and self-confidence.^{39,40} This requires a diagnostic process that combines clinical examination, facial and dentolabial analysis, and careful discussion of expectations. Existing evidence also emphasises the value of communication: clinicians must relate patients' aesthetic wishes to evidence-based, biologically sound treatment options, while ensuring that patients understand the benefits and limitations of each intervention.^{31,35,39-42}

Contemporary aesthetic dentistry therefore combines restorative skill, orthodontic principles, periodontal considerations and psychological awareness. The goal is not to reproduce a universal ideal, but to create an attractive, stable and natural smile suited to the individual patient. By framing dental aesthetics within both psychosocial and clinical dimensions, practitioners can better address the reasons patients seek treatment and can plan care that is ethical, predictable and patient specific.

A further implication is that smile planning should be facially driven rather than tooth driven. Contemporary aesthetic dentistry increasingly recognises that a pleasing restoration may still look unsatisfactory if it ignores facial symmetry, lip posture, smile line or gingival display.³⁵⁻³⁸ This has encouraged a broader approach to assessment, especially in interdisciplinary cases involving orthodontics, prosthodontics, periodontics or restorative rehabilitation. Nevertheless, the expansion of aesthetic dentistry should not lead to overtreatment. Conservative options, preservation of sound tooth structure and respect for long-term function remain essential principles.

Patient expectations have also changed. Many patients now arrive with reference images or with a media-influenced idea of an "ideal" smile. While these concerns are understandable, the role of the clinician is to translate aesthetic goals into a realistic treatment plan that is biologically sound and appropriate for the individual face and dentition.³⁹⁻⁴² In practice, this often means explaining why an attractive result depends on proportion, symmetry, tooth display, colour and gingival harmony together, rather than on a single feature such as whiteness alone.

CONCLUSION

Dental aesthetics has important psychological and clinical implications. Smile attractiveness is influenced by tooth alignment, symmetry, size, colour, incisal display, gingival display, smile arc, lip position and overall facial harmony. Proportional systems such as the golden proportion, RED proportion and golden percentage can support analysis, but none should be applied rigidly. Digital planning tools have improved communication and predictability, yet successful treatment still depends on individualised assessment and sound clinical judgement. A dentistry-centred understanding of smile attractiveness allows clinicians to address both oral health and the psychosocial concerns that frequently motivate patients to seek aesthetic care.

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Artificial intelligence in Dentistry: A new era for radiological insight

SADJ JULY 2026, Vol. 81 No.6 P404-P409

GP Babiolakis,¹ S Shaik,² LM Sykes³

ABSTRACT

Background

Artificial intelligence (AI) has evolved significantly since its inception in the 1950s, revolutionising fields like dentistry through machine learning (ML) and deep learning (DL). ML enables computers to learn from data, while DL, particularly convolutional neural networks (CNNs), excels in complex tasks such as medical image analysis. In dental radiology, AI applications include caries detection (91.5% accuracy), osteoporosis screening (89.29%), and periodontal bone loss assessment (93.09%). AI also aids in orthodontics, prosthodontics, forensic dentistry, and maxillofacial surgery by automating diagnostics, treatment planning, and implant design.

Despite its promise, AI faces challenges, including data scarcity, high computational demands, and ethical concerns regarding transparency, privacy, and accountability. Federated learning has emerged as a solution to protect patient data while enabling AI advancements. While AI enhances diagnostic precision and workflow efficiency, its integration requires collaboration between clinicians and engineers to ensure reliability and mitigate biases. Future research must validate AI's real-world efficacy and address legal and ethical implications to harness its potential in modern dentistry.

Aim

To review and synthesise current applications of artificial intelligence in dentistry, with emphasis on dental and maxillofacial radiology, and to highlight associated challenges and ethical considerations.

Method

A narrative review of the literature was conducted, examining published studies on AI applications in dental radiology

and related dental specialties, including orthodontics, prosthodontics, forensic dentistry, and maxillofacial surgery.

Results

AI systems demonstrated high diagnostic accuracy in dental radiology, including caries detection (91.5%), osteoporosis screening (89.29%), and periodontal bone loss assessment (93.09%). Additional applications include automated diagnostics, treatment planning, implant design, and workflow optimisation across multiple dental disciplines. However, challenges persist, such as limited high-quality datasets, substantial computational requirements, algorithmic bias, and concerns regarding transparency, data privacy, and accountability.

Conclusion

AI has the potential to significantly enhance diagnostic precision and clinical efficiency in dentistry, but its implementation must be cautious, ethical, and evidence-based.

Contribution

This review provides a concise overview of the capabilities, limitations, and ethical implications of AI in dentistry, underscoring the importance of interdisciplinary collaboration and real-world validation for responsible clinical integration.

Keywords

Artificial intelligence, deep learning, dental radiology, CNN, diagnostic imaging, federated learning, explainable AI, dental caries detection, periodontal disease, prosthodontics

INTRODUCTION

The conception of artificial intelligence (AI) emerged in the 1950s to develop computerised machines capable of emulating human cognitive abilities and performing tasks typically executed by humans.^{1,2} This innovation ushered in a milestone called the "Fourth Industrial Revolution". Machine learning (ML) is a specialised domain within AI in which algorithms are used to discern inherent statistical patterns and structures in data, enabling predictions for unseen data.² The neural network (NN) is a type of ML model that excels in handling intricate data formats, surpassing classical ML methods. The foundation of the NN is a digital/artificial neuron, a mathematical construct inspired by a biological neuron. Computers use mathematical operations to assemble and interconnect these artificial neurons, enabling them to tackle specific tasks. This could be used in a dental setting to classify images and determine if the radiographic shows decay on a tooth (Yes) or not (No).³

Over the past seven decades, the practical application of AI has advanced but also encountered formidable obstacles, despite its pioneers' initial enthusiasm. The latter were termed "AI-winters", where the anticipated progress fell short of expectations.³ This was compounded by diminished funding

Author's Information

1. George P. Babiolakis, Consultant, Department of Prosthodontics, University of Pretoria, Pretoria, South Africa
2. Shoayeb Shaik Department of Oral and Maxillofacial Pathology, University of Pretoria, Pretoria, South Africa
3. Leanne M. Sykes, Head of Department of Prosthodontics, University of Pretoria, Pretoria, South Africa

Corresponding author

George P. Babiolakis
Department of Prosthodontics
University of Pretoria
Pretoria, South Africa
Email: u10229982@up.ac.za / babiolakisgeorge@gmail.com
ORCID: <https://orcid.org/0000-0002-5737-3647>

Author Contributions

- George P. Babiolakis – Primary author, 60% contribution
- Shoayeb Shaik – Contributed to manuscript drafting and radiology content, 20%
- Leanne M. Sykes – Supervision, critical revision, and final approval, 20%

Conflict of Interest:

The authors declare no conflict of interest.

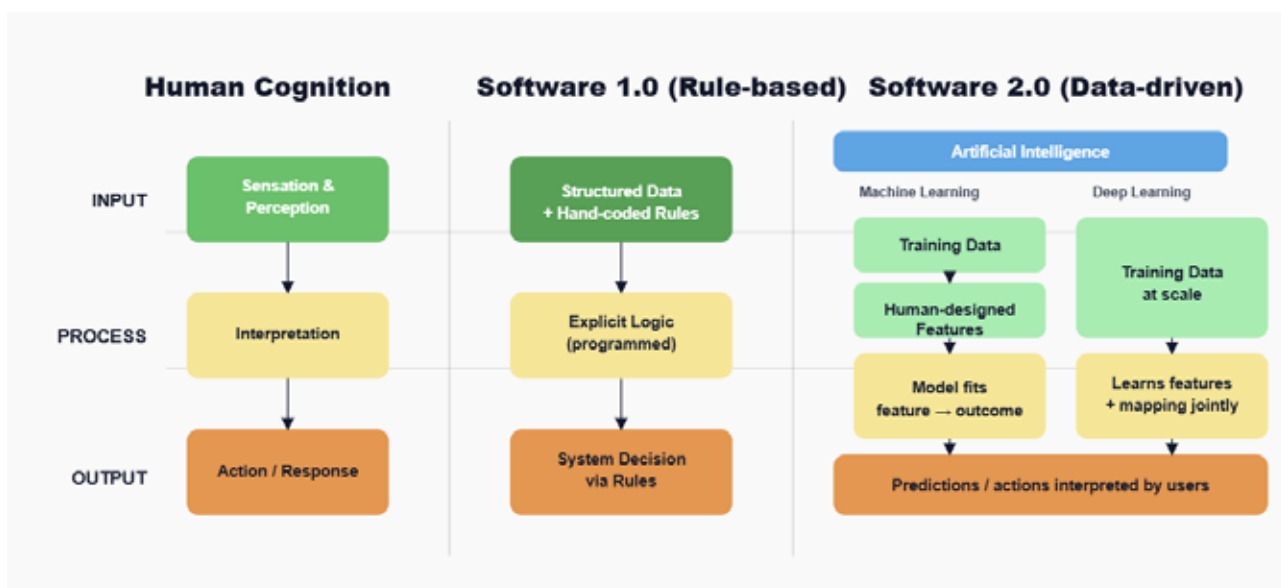


Figure 1: Diagram depicting Natural intelligence computer intelligence (which does not replace human response but supports human interpretation and action). Software 1 depicts the traditional computer, and software 2 depicts AI.

and interest between the two periods, 1974-1980 and 1987-1993. These downturn periods were partly attributed to overly ambitious expectations for AI and to technological constraints at the time, such as limited data accessibility and inadequate computational power to tackle intricate problems.¹

There is currently great optimism regarding AI, mainly due to the remarkable progress made in AI and ML over the past decade. Notably, the output of cutting-edge natural language models (such as ChatGPT and DeepSeek) has reached a level of sophistication that leaves readers struggling to distinguish between human and artificially generated texts.³ Other milestones include deploying autonomous vehicles and passing the Turing test with an AI system, emphasising AI's ever-expanding proficiency, particularly with deep learning (DL).¹

Machine learning and deep learning

Machine learning (ML) is the scientific exploration of computer models that learn from experience rather than being told what to do. This entails giving them examples to learn from, which they then use to make predictions or decisions. Thus, ML requires a data sample to construct a model for rendering predictions/decisions.¹ The learning can be via one of 3 methods: supervised, unsupervised, or reinforcement learning.

- Supervised learning involves obtaining labels for each input and handling classification and regression problems. For example, in medical imaging, expert radiologists provide labels for the images, helping the computer learn to identify specific features or conditions.¹
- Unsupervised learning is when systems learn from data without labels. They independently identify patterns and distributions, handling tasks such as grouping similar data points.¹
- Reinforcement learning algorithms learn from feedback in changing situations. This is common in robotics and video gaming, helping computers "see" things better.

Deep learning is a subset of ML that uses neural networks (NNs) and mathematical models that emulate the brain's neural networks. However, DL's demands for high computational

power pose challenges. Hence, it often uses cropping to a Region of Interest (ROI) from larger images to decrease the computational power needed.⁴ It uses the NNs with a multi-layered design for processing intricate data, such as imaging, and then approximating the functions within certain mathematical constraints. NNs are trained on data points, and, provided they have sufficient data and computational resources, they can learn to capture specific statistical structures and patterns within the data. The model is then optimised to minimise prediction errors, after which it can make predictions of unknown data by processing new data points using what it has learned and from repeated trials.^{3,6} Figure 1 illustrates the differences between the process of natural intelligence, which is characterised by perception, interpretation and response, traditional computer software (software 1.0), which uses rules to generate an outcome, and AI (software 2.0), which uses data and outcomes to infer the rules. In ML, the features are engineered by a human and then learnt (regression modelling), while in DL, the characteristics are learned in a single step and then correlated without human interference, allowing for processing complex data and structures like images.³

Advancements in artificial intelligence have led to the emergence of DL algorithms, with particular emphasis on convolutional neural networks (CNNs).¹ These advanced computer systems have open-source software programs for object detection, including region-based CNN (R-CNN), You Only Look Once (YOLO), and DetectNet. Among these, faster R-CNN is the most extensively studied. However, R-CNN requires more substantial computational power while offering superior detection accuracy.⁵ Al-Masni *et al.*⁶ explored YOLO; this system partitions images into grids for object recognition, offering rapid processing speeds, albeit with somewhat lower accuracy than R-CNN.^{5,6} DetectNet is another CNN created independently by NVIDIA. DetectNet has demonstrated impressive performance.⁵ The architecture of DetectNet closely resembles GoogLeNet, with minor differences in input, last pooling, and output layers.⁵

Many of the mentioned systems have shown promise in medical imaging, including dental radiology, by automatically

analysing radiographic images, facilitated by object detection and classification.⁷ These ML techniques have revolutionised medical diagnostic capabilities across various specialties, such as cardiology, oncology, and neurology, where they have been used in the early detection of diseases like Parkinson's disease, thyroid disease, hepatitis, and breast cancer, surpassing human judgment in accuracy.² Within dentistry, ML techniques may be used to address challenges in disease prevention and treatment planning and have also been applied to oral cancer detection, dental caries diagnosis, periodontal disease treatment, and orthodontic planning.² Many AI software systems have surfaced, each aiming to evaluate dental conditions using different dental radiographs, including panoramic, peri-apical, and dental cone-beam computer tomography(CBCT) scans. They may be used to distinguish between healthy dentition and cases involving prostheses or missing teeth, as well as between permanent and mixed dentition, facilitating more precise communication regarding the dental treatment needed.⁸ They could also potentially be used to automatically detect teeth in panoramic radiographs and then use algorithms to classify them based on pathology and treatment status. This will allow clinicians to obtain comprehensive dental information about patients. Given that Panoramic radiography is used extensively in dentistry, with millions of images acquired annually, it is a natural choice for the development of automated diagnostic systems. Future uses include detecting cystic lesions, impacted teeth, fractures, and maxillary sinusitis, as well as aiding post-mortem identification, which is helpful after large-scale natural disasters.^{4,4} There is already software available for tooth numbering and charting from panoramic radiographs, which can enhance diagnostic precision while decreasing the workload on dentists.⁸

As AI has expanded, it has revolutionised dental and maxillofacial radiology by enhancing workflow efficiency and accuracy.⁹ Recent studies indicate impressive accuracy rates in AI detection across various dental conditions:

- Carious teeth (91.5%)⁹
- Osteoporosis (89.29%)⁹
- Maxillary sinusitis (87.5%)⁹
- Periodontal bone loss (93.09%)⁹
- Numbering and identification of teeth (93.67%)⁹
- Detecting periapical lesions 99.95% (sensitivity) and 92% (specificity)⁹

However, debates have surfaced over the reliability of AI diagnoses and the rationale behind their judgments. Therefore, we must ensure that AI development is explainable while acknowledging that human input remains imperative. Additionally, mitigating the potential misuse of AI regarding diagnosis warrants urgent consideration.¹

The use of AI in Dental Radiology

The remainder of this paper will focus on the applications of AI in dental radiology, including its operational mechanisms, potential uses across different dental applications, and emerging ethical considerations. Figure 2 shows a diagram of how a DL system learns to identify tooth decay in radiographic images. It does this by repeatedly analysing data to reduce mistakes between its predictions and the actual labels, gradually improving over time.¹

The applications of CNNs in radiology can be further broken down into various categories, including classification, detection, and segmentation.¹

Classification involves a broad spectrum of tasks, from identifying whether a disease is present to determining the type of malignancy.¹

Detection entails identifying and pinpointing areas within lesions or specific anatomical features in radiographs. It is based on similar principles to those used in classification, but it has additional layers with functionalities such as region proposals and regression models to aid disease recognition.¹ Segmentation is used to partition anatomical features or lesions in radiographs obtained via various modalities, such as routine dental radiography, CT scans, MRIs, and ultrasound.¹

Collecting and labelling data

Integrating AI for automated interpretation is financially burdensome, requiring large data volumes and processing power. It also demands high accuracy and meticulously labelled, high-quality datasets, which require the time and effort of experts in the field to provide these labels.¹ This accuracy or "ground truth" refers to the reliability of the inserted reference values. There are two main ways labels may be generated: manual annotations by radiologists during image review or extraction from radiology reports.¹

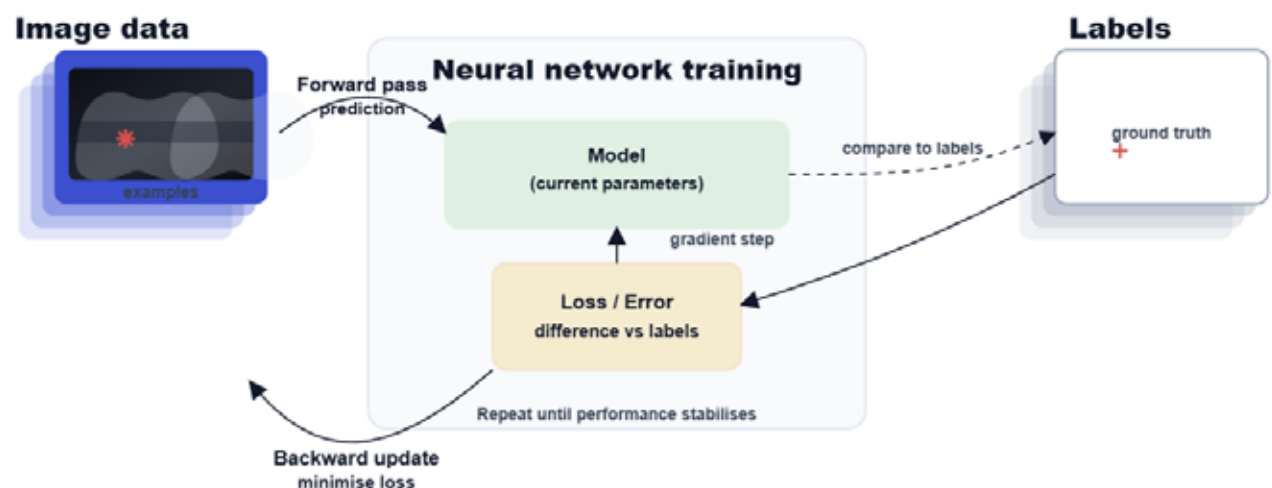


Figure 2: Diagram illustrating deep learning for caries segmentation in periapical X-ray images. Through iterative steps involving forward propagation (prediction) and backward propagation (error minimization).

Throughout this label creation process, a team of radiologists needs to have a consensus regarding labelling standards to ensure accurate ground truth. They should use intra- and inter-class coefficients to assess agreement, and the label format and tools should align with the task requirements and the DL model. Effective communication between radiologists and engineers developing deep-learning applications is essential for determining the appropriate label type.¹

It may also be challenging to obtain adequate case samples for labelling. Thus, data augmentation techniques have been used to address this issue. This involves modifying the dataset while retaining the same labels. These modifications can include cropping, flipping, rotating, translating, zooming, skewing, elastic deformation, and adjustments of contrast or resolution. Further, recent advancements in synthetic data augmentation using Generative Adversarial Networks (GANs) have shown promise in mitigating data scarcity issues across various classification, detection, and segmentation tasks.¹

Data processing for the learning process

As explained below, labelled data is typically split into training, validation, and test datasets. Note that there must be no overlap between the training, validation and test data: ¹

- The training data trains the learning model and fine-tunes its parameters.
- The validation data set monitors the model's performance during training and helps identify the optimal method.
- Test data checks the final result and performance.

The required dataset size depends on the task's nature and complexity.¹ After training, a cross-validation method is used to gauge and generalise the effectiveness of the trained model, particularly in situations where datasets are limited in size. In k-fold cross-validation, the training dataset is partitioned into k equal subsets. This approach allows one part of the data to be set aside as a validation set, and the remaining data is then divided into k- 1 subsets for training. The AI model is trained using these subsets and evaluated on the validation set. This cycle repeats k times, utilising a different validation set each time. The final performance is calculated based on the average of these evaluations. Sometimes, the validation set is skipped, and the data is split into training data and test data (Figure 3).¹

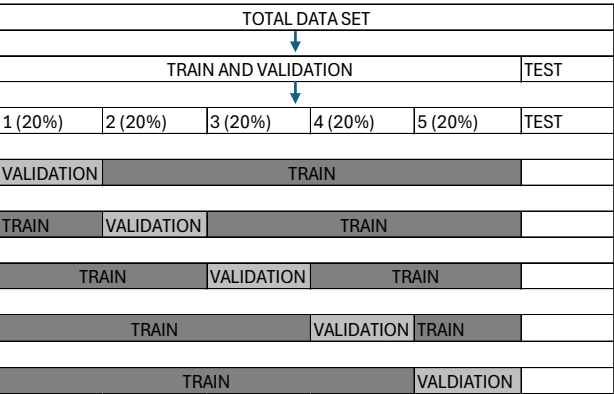


Figure 3: An illustration of fivefold cross-validation: The entire dataset was partitioned into training, validation, and test datasets for an artificial intelligence study.

In OMFR, investigations have assessed the value of AI in diagnosing various conditions. In the 1990s, White initiated work on software that entered a patient's clinical

and radiographic data, yielding a list of potential differential diagnoses. This is known as the ORAD diagnosis system, now in its second version, ORAD II, which enhances differential diagnosis capabilities for OMF diseases.¹

In 1999, Park *et al.*¹⁰ conducted a study using an artificial neural network (ANN) system to assess cervical lymph node metastasis of oral squamous cell carcinoma. The study involved identifying and inputting MR imaging characteristics of lymph node metastasis into the system and assessing the results.

Their research revealed that the ANN system outperformed individual MR imaging criteria.¹⁰ Since then, many more studies have assessed the accuracy and reliability of DL techniques in diagnosing various dental conditions such as caries, periodontal disease, vertical root fractures, periapical pathosis, and jaw bone cysts and tumours.¹¹ It is also used in general dentistry, endodontics, orthodontics, and forensic dentistry. Dental panoramic radiographs were the most used, followed by periapical radiographs, cephalometric radiographs, and cone-beam CT or conventional CT scans. The dataset sizes ranged from 10 to 5166 images, with an average of 1053.12. Most studies focused on tasks such as automatically pinpointing cephalometric landmarks, assessing markers for osteoporosis, categorising maxillofacial cysts and tumours, and detecting periodontitis/periapical disease.¹³

Other AI models have been developed to identify and trace the inferior alveolar nerve, remove artefacts on CBCT images, and refine blurry radiographs using modified post-processin.

AI in other dental fields

AI in Forensic Dentistry

Forensic dentistry is fundamental in estimating age, determining sex, and identifying unknown individuals. Researchers have explored the use of dental radiographs for extracting evidence from teeth, but these images are known for suboptimal image quality, low contrast, and potential superimposition and distortion. However, obtaining pertinent evidence via traditional clinical methods is labour-intensive and prone to inaccuracies, observer errors, and subjective interpretation.¹ In resolution, researchers have devised automated AI-based methods¹

Traditional age estimation uses radiology-based techniques that are non-invasive and accurate to analyse teeth in living and deceased individuals. They can also help assess developmental and degenerative changes in teeth and their supporting structures. These conventional methods involve multiple processes and are susceptible to observer influence and thus error. Studies have proposed automated methods for evaluating third molar development, dental age estimation, and sex prediction algorithms to support more objective decision-making. While current research predominantly focuses on age estimation, the future holds potential for AI innovations across various forensic domains.¹

AI in Orthodontics

Orthodontics is one of the fields most influenced by AI. In the past, cephalometric analysis was critical for treatment planning. This can now be enhanced by automatic segmentation of CBCT scans and automatic 3D cephalometric analysis.¹⁴ Future applications may allow AI prediction of facial growth and ageing and tooth movement during aligner treatment,

which could lay the foundation for AI-driven tooth movement. AI in orthodontics also assists with patient communication, coaching, and clinician oversight.¹⁴

AI in Oral and Maxillofacial Surgery

In maxillofacial surgery, AI can assist with imaging modalities such as CT, CBCT, and MRIs to visualise facial anatomy and pathology, aid in diagnosing conditions, detect head and neck cancers, help make treatment decisions, and be used in combination with radiomics for surgical planning and outcomes prediction. Radiomics involves extracting and analysing imaging features from CT, CBCT, and MRI scans. Thus, AI can complement human expertise and help reduce errors, but improving tissue prediction requires more relevant 3D data.¹⁴ Researchers have therefore advised that as AI's potential in oral and maxillofacial surgery continues to proliferate, maxillofacial surgeons should gather as much virtual data as possible to enable them to integrate AI into clinical practice.¹⁴

AI in Therapeutic Dentistry

AI can assist in detecting diseases and identifying dental cavities on radiographs, thereby supporting diagnosis. It can also label teeth on radiographs and prepare dental charts. The accuracy and effectiveness of AI in this realm need more research in real-world dental practice.¹⁴

Muramatsu *et al.*¹⁵ examined the possibility of detecting osteoporosis on panoramic radiographs by measuring mandibular cortical width. They found that using CAD and quantitatively measuring mandibular cortical width enabled them to identify osteoporotic patients with 88.5% sensitivity and 97.3% specificity. They indicated that their AI model could flag patients at risk of osteoporosis and recommend further evaluation.¹⁵

AI in Periodontology

Periodontal disease is a common cause of tooth loss and a significant public health concern. AI has become increasingly important. Using automated search methods, AI software can sort large amounts of data to find patterns related to periodontal disease. By combining AI with different types of information, we can better diagnose periodontal problems. Additionally, AI helps improve oral hygiene habits with new tools, such as wrist sensors that track brushing and flossing.¹⁴

In a recent development, Chang *et al.*¹¹ devised an automated method to categorise periodontitis stages using dental panoramic radiographs, employing a hybrid DL approach. Their AI system combined DL with traditional computer-assisted methods. They found the accuracy and consistency high when automatically identifying periodontal bone loss and staging periodontitis based on the severity of alveolar bone loss.¹¹

AI in Endodontics

In endodontics, AI has assessed the number and configuration of root canals. The DL system, mainly using AlexNet and GoogleNet architectures, exhibited high accuracy, sensitivity, and specificity in distinguishing between single and additional roots on teeth using only panoramic images. Interestingly, the DL system outperformed trained radiologists in specificity.¹⁶ It can also help identify pathology such as periapical lesions and thus better clinicians' treatment outcome predictions.¹⁷ When used with CBCT technology, it can surpass the human eye for detecting vertical root fractures.¹⁷ However, the

widespread use of CBCT is limited due to costs and radiation concerns. Hariwa *et al.*, thus, suggested that predictive DL models should be applied to panoramic radiographs first to try and identify patients who truly require CBCT.¹⁶

AI use in Cleft Lip and/or Palate, and other Syndromes

Research is ongoing on using AI to estimate the likelihood of someone having a cleft lip and/or palate (CLP) deformity, and even to identify genetic and environmental factors that might contribute to its development across different groups. While detecting a cleft lip in prenatal ultrasounds is usually straightforward, finding a cleft of the palate or other intraoral defects before birth is more complicated. AI shows promise in helping with this. After birth, AI can help clinicians detect and classify a cleft lip with or without a cleft palate on radiographs. This may be more accurate and is less invasive and traumatic to the infant than a clinical examination. It can also help surgeons estimate the size of a cleft before reconstructive surgery, aiding treatment planning.¹⁴ In older children, AI-powered speech assessment focuses on the severity of the speech problems that can assist in speech therapy.¹⁴

AI in Prosthodontics

In prosthodontics, AI programs have been developed to include automated diagnostics, predictive modelling, and classification tools. Digital dentistry now encompasses almost every facet of prosthodontics, as listed below:

- Intraoral scans can replace traditional impressions, with reportedly better accuracy and efficiency in certain situations. Such as single-crown or short-span bridges.¹⁴
- Digital scanning programs allow for the automatic removal of excess soft tissues and materials, streamlining workflow.¹⁴
- In fixed prosthodontics, AI algorithms help locate prep margins, allowing them to be adjusted later.¹⁴
- Computer-aided design and computer-aided manufacturing (CAD/CAM) technology help design and make dental restorations, using ML to make better crowns and predict when restorations might come off.¹⁴
- It can examine dental arches for removable prosthodontics and use ML to help set up denture teeth, allowing edentulous patients to see what arrangements may look best in their mouths.¹⁴
- Digital spectrophotometers can help the human eye match tooth colour, improving aesthetics.¹⁴
- In implant prosthodontics, AI shows promise in identifying and classifying dental implant systems.¹⁸ Scanners can examine the root morphology of remaining teeth, allowing clinicians to plan the best position and angulation of implants and assist in selecting implant designs.¹⁷
- They are commonly used to evaluate bone quantity and quality and identify the Inferior alveolar nerve or other anatomical landmarks that need to be noted before implant placement.^{14, 17}
- Smile design uses AI to plan treatment, combining 3D data from X-rays, scans, and face scans to plan how someone's smile could look after rehabilitation.¹⁴
- Another common patient issue is tooth surface loss, for which AI models, such as artificial neural networks, can predict the occurrence and rate of progression with reasonable accuracy.¹⁴

Ethical considerations of using AI in dentistry

The rapid expansion of Artificial Intelligence in dentistry offers promising clinical benefits but also introduces significant ethical, legal, and social challenges. A framework proposed

by Rokhshad *et al.*¹⁹ outlines eleven key principles necessary for AI's ethical development and deployment, including transparency, accountability, privacy protection, equity, and governance. These principles aim to protect patient interests and ensure responsible innovation.

A fundamental ethical concern is transparency, specifically the inability of deep learning models to explain their decision-making. Many current AI systems function as "black boxes," producing outputs without clear justification for their predictions. This is particularly problematic in clinical settings, where practitioners must justify diagnostic or treatment decisions. The development of Explainable AI (XAI) has gained traction to address this. XAI provides interpretable outputs, such as visual heatmaps on radiographs, that help clinicians understand what regions or features influenced the AI's decision. This fosters trust, supports shared decision-making with patients, and provides an audit trail in the event of diagnostic error.^{3, 19}

Another primary concern is data privacy, especially given the sensitivity of medical records. Traditional AI development relies on centralised datasets, which can pose a risk of confidentiality breaches. Federated learning has emerged as a viable solution. In this model, AI is trained on decentralised data across local servers, with only encrypted model updates shared among systems. This enables collaborative AI development without transferring raw patient data, upholding privacy standards while benefiting from diverse datasets.^{3, 20} However, federated learning still faces technical challenges, including the need for high-performance local hardware, efficient communication networks, and robust cybersecurity infrastructure to prevent breaches.²⁰

Collectively and individually, manufacturers, regulators, dentists, and patients are responsible for ensuring AI's ethical and sustainable implementation in dentistry. However, significant challenges remain. The high cost of AI development may limit access, exacerbating existing inequalities in healthcare delivery. Furthermore, legal liability becomes ambiguous if an AI system generates an incorrect diagnosis. Should accountability fall on the developer, the radiologist who interpreted the results, or the clinician who implemented treatment based on AI guidance? These grey areas emphasise the need for clear legal frameworks and underscore the risk of over-reliance on AI at the expense of sound clinical judgment.²¹

Ultimately, while AI has the potential to enhance diagnostic accuracy and improve patient outcomes, it must not replace the critical thinking and ethical responsibility of human clinicians. Its integration into dentistry must be grounded in fairness, transparency, data security, and shared accountability. Close collaboration between engineers, clinicians, ethicists, and policymakers will ensure that AI technologies serve professional integrity and public trust.

CONSIDERATIONS AND CONCLUSIONS

Artificial Intelligence is poised to revolutionise dentistry, particularly in diagnostic radiology, prosthodontics, orthodontics, endodontics, and maxillofacial surgery. Its capacity to detect carious lesions, periapical pathology, bone loss, and anatomic variations with high accuracy has the potential to support clinical decision-making and improve patient outcomes.^{1, 9}

Nonetheless, the real-world application of AI systems is challenged by issues related to dataset quality, the need for expert-labelled training data, and concerns about algorithmic bias.² Successful integration depends not only on technical performance but also on ethical, legal, and practical considerations.

Federated learning significantly advances privacy and performance, allowing collaborative AI training across institutions without transferring raw data.^{3, 20} Explainable AI (XAI) complements this by promoting transparency and trust, helping clinicians understand how decisions are derived, an essential factor in healthcare environments that demand justification for every action.³

The interdisciplinary collaboration between dental professionals, engineers, ethicists, and policymakers will be vital. AI should remain a supportive tool that enhances human capability, not replace it. Continuous research, patient education, and clinician training are essential to ensure that AI's integration is safe, beneficial, and ethically sound.

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Orthodontic–Surgical Correction of Bimaxillary Protrusion: A Decade-Long Case Report

SADJ JULY 2026, Vol. 81 No.6 P410-P416

E Ghabrial,¹ T Irene Munzhelele,² Ashraf Ayoub³

ABSTRACT

Objective

To present a 10-year follow-up case report of an adult Black African female with severe bimaxillary protrusion (BP) treated using combined orthodontic treatment, anterior segmental osteotomy (ASO), and osseous advancement genioplasty, with an emphasis on long-term facial aesthetics, dental and skeletal stability.

Methods

The patient presented with a convex profile, lip incompetence with prominent mouth breathing and incisor proclination, with thin labial cortical bone compromising the potential for safe orthodontic retraction. Pre-surgical orthodontic decompensation was followed by maxillary and mandibular ASO with advancement genioplasty. CBCT imaging was used for both treatment planning and post-treatment evaluation. Cephalometric and soft tissue changes were assessed at 10 years.

Results

The combined surgical–orthodontic protocol yielded significant improvements in facial balance, lip competence

and occlusal relationships. CBCT evaluation at 10 years confirmed the preservation of the alveolar bone, periodontal stability, and the absence of root resorption. The patient reported sustained satisfaction with facial aesthetics and function.

Conclusion

This case supports the efficacy and long-term stability of fixed orthodontic treatment combined with anterior segmental osteotomy (ASO) and genioplasty in a carefully selected adult patient presenting with bimaxillary protrusion and limited alveolar bone housing. The combined approach yielded superior aesthetic outcomes, minimised the risk of alveolar dehiscence and preserved periodontal health. These results underscore the importance of individualised surgical planning guided by cephalometric and soft-tissue analyses, while also promoting a patient-centred approach to care.

INTRODUCTION

Bimaxillary protrusion (BP) is a dentoalveolar deformity due to the proclined incisors and the anteriorly positioned dentoalveolar segments. It is recognised by the proclined upper and lower incisors, also associated with decreased interincisal angles, protrusive lips, and reduced nasolabial angles. The lip incompetence and a convex soft tissue profile are among the most characteristic features.¹ It is more prevalent among African and Asian populations. The main concerns of patients seeking BP correction are lip incompetence and facial convexity, regardless of occlusal relationships.^{2,3}

The management of bimaxillary protrusion can lead to patient dissatisfaction from an aesthetic perspective if it is based solely on orthodontic biomechanics.⁴ Therefore, the comprehensive multidisciplinary approach is essential, taking into consideration facial harmony and patient-specific aesthetic goals.⁵ Bimaxillary protrusion (BP) may be part of any of the skeletal classifications, including Class I, II, and III.⁶ Using lateral cephalometric analysis, BP can be managed with orthodontic camouflage, involving the extraction of a first premolar and maximum anchorage retraction, which is widely used to manage most of the moderate BP cases.^{7,8} However, excessive retraction, particularly in patients with thin alveolar bone, risks dehiscence, root resorption and soft tissue instability, especially in adults.⁹ Contrary to this, surgical correction via anterior segmental osteotomy (ASO) offers better soft tissue changes and stable incisor repositioning.^{2,10} Furthermore, adjunctive osseous genioplasty is usually necessary to address lip incompetence, lower facial imbalance and mentalis strain, which improve post-surgical oral health and quality of life markedly.¹¹

Authors' information

1. Emad Ghabrial. BDS, MChD(Ortho), PhD, H Dent Dip, PG Dip Dent (P.Manag), FDS RCPS (Glasg). Orthodontist. Department of Orthodontics, University of Pretoria (UP) Steve Biko & Dr Savage Rd, Riviera, Pretoria, 0084. Tel +27 (0)12 319 2609, Fax +27 (0)86 580 6128. Email: emad.ghabrial@up.ac.za. ORCID: <https://orcid.org/0000-0002-7213-9760>
2. T Irene Munzhelele, BChD, MBChB, MChD Max-FAX MED, FCMFOaa, Dip Odont, PGDHSE. Maxillofacial & Oral Surgeon. Tel +27 (0)12 521 4858. Email: irene.munzhelele@smu.ac.za. ORCID: <https://orcid.org/0000-0002-0082-9391>
3. Prof. Ashraf F Ayoub, PhD, MDS, FDS RCS(Ed) FDS RCPS (Glasg) Oral & Maxillofacial Surgeon. The University of Glasgow, UK. Tel: 0044 141 211 9649. Email: Ashraf.Ayoub@glasgow.ac.uk. ORCID: <https://orcid.org/0000-0002-2760-6008>

Corresponding author

Name: Emad Ghabrial
 Tel +27 (0)12 319 2609,
 Fax +27 (0)86 580 6128.
 Email: emad.ghabrial@up.ac.za

Authors contribution

1. Emad Ghabrial – Conceptualisation, retrieved the case, writing and editing: Main author
2. T Irene Munzhelele – Writing and editing: Co-author
3. Prof. Ashraf F Ayoub – Clinician writing and editing article 10%

Given the limitations of orthodontic retraction in adults with thin alveolar housing and the proven advantages of anterior segmental osteotomy combined with osseous genioplasty for achieving stable skeletal and soft-tissue outcomes, this case report exemplifies successful management of BP. The management protocol included preoperative orthodontic treatment to decompensate dentition, followed by surgery and postoperative orthodontics. We present a 10-year follow-up of comprehensive BP management. Protrusion: Demonstrating long-term aesthetic and functional stability and reinforcing the importance of multidisciplinary management of BP.

CASE REPORT

Patient History

A 40-year-old patient presented with BP; her main concern was protrusion and difficulty in achieving a lip seal. She expressed dissatisfaction with her profile and a desire to improve facial harmony. Her medical history was non-contributory, and she reported no history of temporomandibular joint (TMJ) pain or parafunctional habits. Oral hygiene was good; no active caries or periodontal disease was noted at presentation. The patient reported that her malocclusion had persisted since adolescence.

Clinical Examination

The patient's profile was convex with mentalis strain and lip incompetence with an everted vermilion border and interincisal gap of 2mm (Figure 1). Facial and smile analysis

revealed a convex soft tissue profile characterised by lip incompetence and mentalis strain. Mild to moderate maxillary incisal display was evident at rest, with increased incisal and gingival show on smiling, consistent with the underlying dentoalveolar protrusion. The maxillary and mandibular dental midlines were coincident and aligned with the facial midline, with no clinically significant deviation. The occlusal plane appeared level, with no evidence of occlusal canting relative to the interpupillary line. Overall facial symmetry was preserved, with no marked skeletal or soft tissue asymmetry. Mild paranasal hollowing was noted, contributing to reduced midfacial support, while nasal assessment demonstrated no significant deviation and maintained symmetry (Figure 1). The occlusion Angle Class 1 with mild crowding of the anterior teeth. The SNA angle was 80.0°, SNB was 75.0°, and the ANB was 5.0°, indicating a skeletal Class I relationship. The mandibular plane angle relative to the SN was 43.0°, and the Y-axis angle measured 75.0°, both consistent with a vertical growth pattern. Maxillary incisors were proclined at 38.0° to NA and mandibular incisors at 48.0° to NB, with an interincisal angle of 91.0°, confirming bimaxillary dentoalveolar protrusion with vertical facial growth tendencies. The lateral cephalogram revealed a noticeably thin alveolar bone over the maxillary and mandibular incisors. Soft tissue analysis showed a facial contour angle of -12.0° and a Holdaway angle of 25.0°, indicating a retruded soft tissue pogonion (Table 1). A panoramic radiograph confirmed the presence of third molars, with no other significant findings (Figure 1).

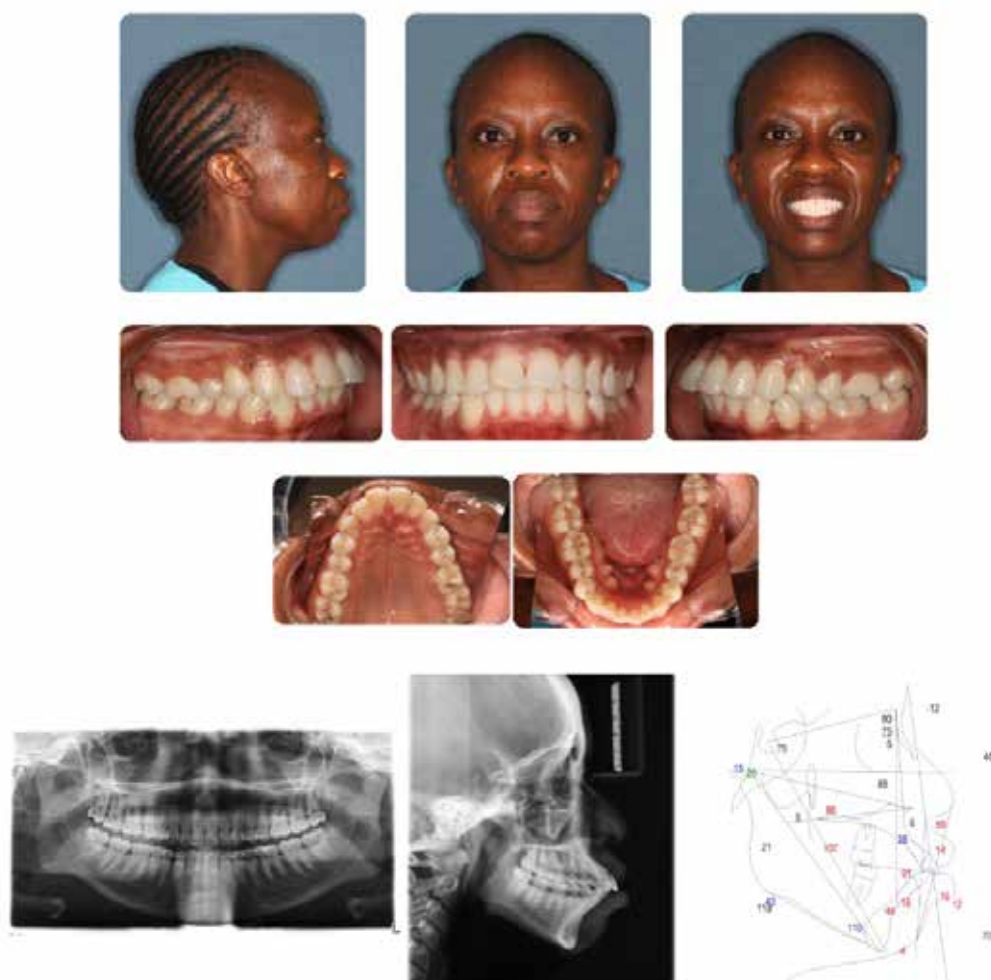


Figure 1: A 34-year-old adult Black African female patient's pre-treatment records

Table I: Pre-treatment and post-treatment cephalometric measurements

	Measurement	Norm	Pretreatment	Post-Treatment
Maxilla	SNA (°)	82.0 ± 3.5	80	77
	Convexity (A-NPO) mm	5.7	6	3
Mandible	SNB (°)	80.0 ± 3.4	75	75
Intra-arch	ANB (°)	2.0 ± 1.5	5	2
Vertical Dimension	MPA (SN-GoGn) (°)	32.0 ± 5.2	43	42
	Y-Axis (SGn-SN) (°)	67	75	75
	UFH (Na-ANS) (mm)	46	48	47
	LFH (ANS_Me) (mm)	60	70	69
Dental	U1-NA (°)	22.8	38	27
	U1-NA (mm)	4.3	14	9
	L1-NB (°)	25.3	48	31
	L1-NB (mm)	4	16	8
	IMPA (LI-MP) (°)	95	110	93
	U1-L1 (°)	123	91	120
Soft tissue	Lower lip to E-line (mm)	-2.0 ± 2.0	12	0
	Holdaway angle PG-NA/ PG - Ls (°)	8	25	14
	FCA (°)	-9.5	-11	-1
	Nasolabial Angle (°)	102	59	67

Treatment Objectives were to improve the protrusive profile without worsening mentalis strain, achieve a stable occlusion, and achieve an aesthetically pleasing smile.

Treatment Plan

Based on the patient's condition and goals, we considered the following approach:

- Comprehensive orthodontic treatment combined with maxillary and mandibular anterior segmental osteotomy, along with the extraction of all four first premolars.
- Orthodontic decompensation was achieved with a fixed appliance to position the teeth over their respective basal skeletal structures, thereby allowing precise surgical alignment and improved facial aesthetics. Levelling and alignment were initiated with a standard 0.018-inch edgewise appliance using round archwires. Six months after aligning the maxillary and mandibular anterior teeth, arch coordination was performed using 0.017 × 0.022-inch rectangular stainless-steel wires. The total duration of presurgical orthodontic treatment was 14 months (Figure 2).

The orthodontic preparation was achieved with levelling and aligning of the teeth, maintaining the Angle class I molar relationship.

Surgical Planning and Patient Consent

Simplified plaster model surgery planning was carried out, during which it was preplanned that 5mm of bone should be removed to reduce the prominence and the show of the upper incisors.

An anterior segmental osteotomy (ASO) was performed on both the maxilla and mandible.

Surgical approach followed the method described by Cupra in 1954 for the maxilla and the Modified Köle procedure for the mandible.^{12,13}

Maxillary Osteotomy (Wasmund Approach)

A horizontal vestibular incision was made, with two vertical incisions posterior to the first premolars. Extraction of the upper first premolars was performed during osteotomy. Palatal subperiosteal tunnelling from the extraction sites,

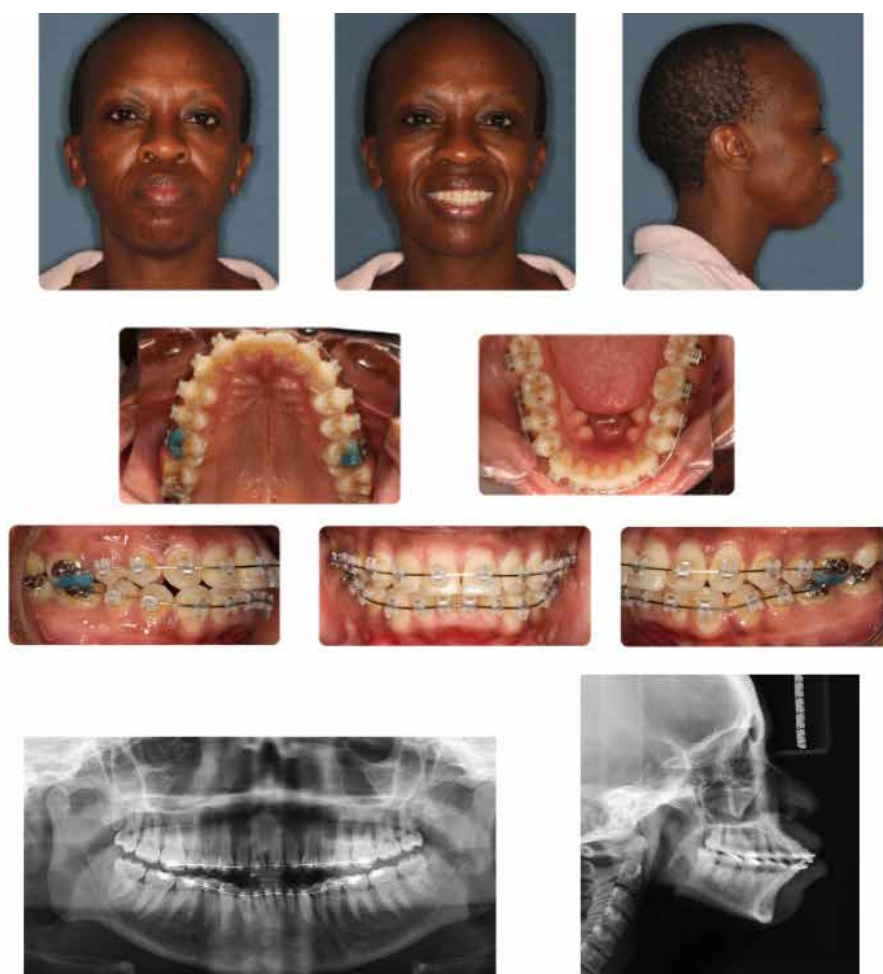


Figure 2: Pre-Surgical records

joining at the midline, guided the palatal osteotomy to safeguard the blood supply. A separation of the premaxilla was achieved once it was separated from the nasal septum. Bone removal was achieved using a surgical burr to allow premaxilla repositioning superiorly and posteriorly. Point A (subspinale) was set back by about 3 mm. An occlusal wafer was made from San-splint Ezeform thermoplastic Polyform (Smith & Nephew) during the procedure. L-shaped titanium mini-plates were used for fixation, one on each side. A cinch suture was placed to narrow the alar base.

Mandibular Osteotomy (Modified Köle Procedure)

The planned posterior surgical movement was 7 mm. An alveolar osteotomy of the lower lower anterior segment, combined with advancement genioplasty, were performed. Vertical osteotomies were done at the sites where first premolars were extracted and joined horizontally about 5 mm below the apices of the anterior teeth. Bone was removed to allow proper positioning of the osteotomy segment. The anterior mandibular segment was moved posteriorly as planned and the genial segment was moved forward. Fixation was achieved using two titanium mini plates, one on each side (Figure 3), and temporary bridal wire between the canine and the premolar. The mentalis muscles and the mucoperiosteum were sutured in layers.

Postoperative Orthodontic

Following surgery, intermaxillary vertical elastics were applied

to guide and maintain optimal occlusion during the healing phase. The orthodontic appliances and elastics were removed. The patient then entered the orthodontic retention phase, which included fixed retainers bonded to the upper and lower anterior teeth and a removable Truretain overlay retainer for nighttime wear.

Post-Treatment Evaluation and Follow-Up

The patient achieved a satisfactory occlusion and notable improvement in facial aesthetics. Lip competence was restored, resulting in prominent nasal breathing, with no evidence of mentalis muscle hyperactivity. A post-treatment panoramic radiograph did not show signs of root resorption or periodontal bone loss between osteotomy segments (Figure 3). Retention was maintained using a removable Truretain retainer and bonded retainers on the anterior teeth of both arches.

Post-treatment cephalometric analysis (Table 1) demonstrated improvement of maxillary incisors' labial inclination to 27.0°, and the mandibular incisors to 31.0° relative to the NB line. Significant changes in soft tissue profile include improved lower lip protrusion relative to the E-line, from 12.0 mm to 0.0 mm; interisal angle, from 91° to 120.0°; and Holdaway angle, improved to 14.0° (Table 1). The superimposed cephalometric tracing illustrates the changes achieved with the treatment (Figure 5). At the 10-year follow-up appointment, the patient maintained stable intercuspation, a

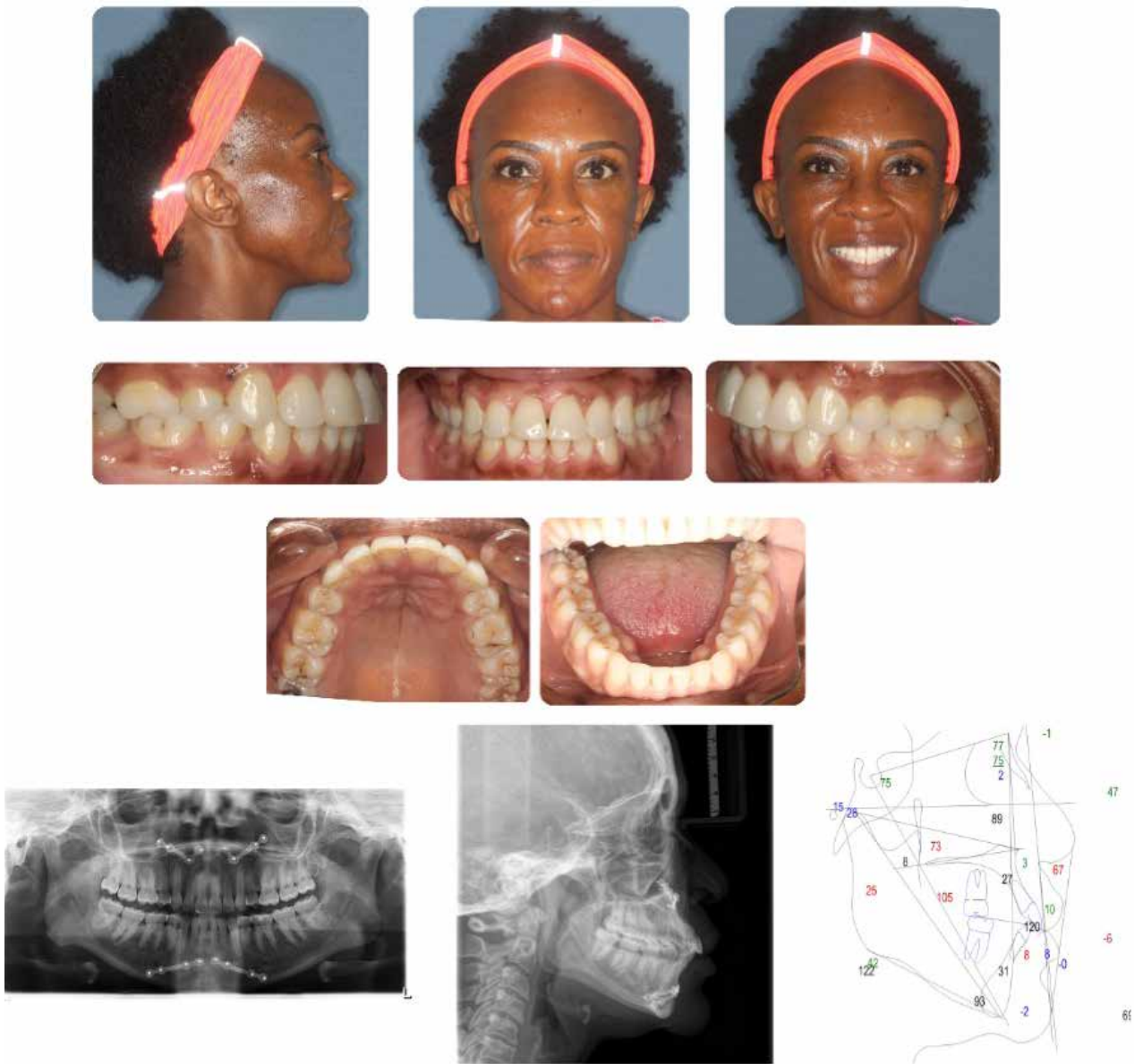


Figure 3: Post-treatment records

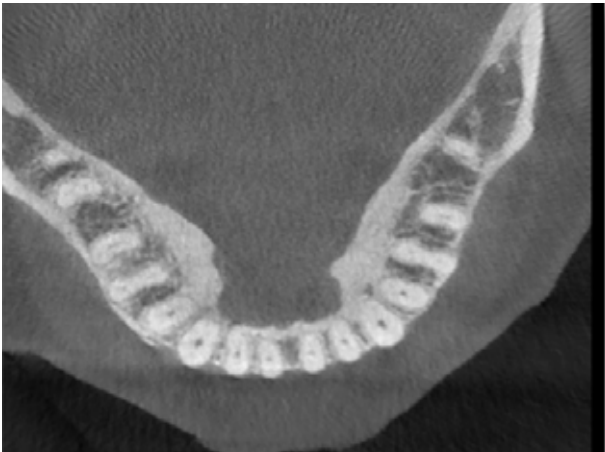


Figure 4: CBCT image demonstrating intact cortical bone on the lingual side of the mandibular incisors.

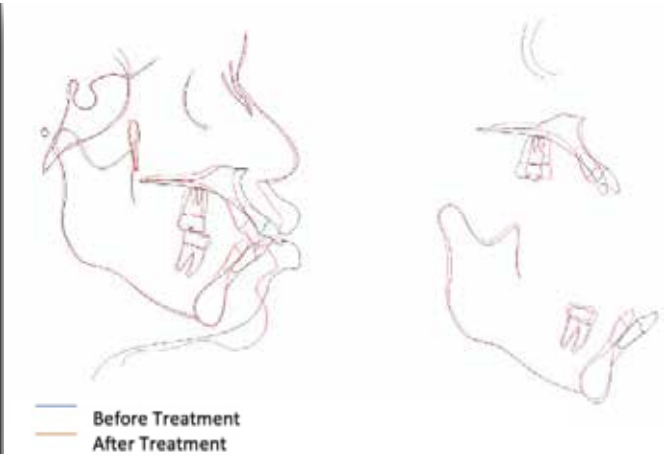


Figure 5: Superimposition (on the SN plane and registering on sella) of lateral cephalometric radiographs before and after treatment

harmonious facial profile, and healthy periodontal conditions adjacent to the osteotomy sites. The patient was pleased with the functional and aesthetic outcomes of the treatment.

DISCUSSION

This case highlights the value of a multidisciplinary treatment strategy involving both orthodontic and maxillofacial surgeons for the management of bimaxillary protrusion (BP). The integration of anterior segmental osteotomy (ASO) and osseous genioplasty, combined with pre- and post-surgical orthodontic treatment, achieved notable enhancements in facial aesthetics, including reduced lip prominence, alleviation of mentalis strain and restoration of lip competence. Skeletal and periodontal stability were maintained over a 10-year follow-up period, as confirmed by CBCT imaging (Figure 4). This report contributes to the growing body of literature supporting the orthodontic-surgical approach of ASO in conjunction with genioplasty, particularly in patients with limited alveolar housing. It highlights the importance of comprehensive pre-surgical planning and underscores the potential for long-term functional and aesthetic stability, leading to high patient satisfaction.^{14,15}

The outcomes align with findings by Baek and Kim,² who demonstrated that ASO provides superior incisor retraction and lip response compared to OR, which is often associated with adverse effects such as root resorption, alveolar dehiscence and anchorage loss.³ Importantly, osseous genioplasty in this case contributed not only to aesthetic improvement but also to maintaining perioral function, enabling spontaneous lip closure without overactivation of the mentalis muscle.^{16,17} These findings align with studies by Rustemeyer, who reported enhanced lower facial balance and improved psychosocial outcomes following combined genioplasty and bimaxillary surgery.¹¹ In addition, genioplasty has been associated with improved respiratory function by promoting lip competence and facilitating nasal breathing, thereby contributing to the procedure's functional and aesthetic benefits.^{16,18}

Orthodontic treatment is limited to tooth alignment without surgical intervention. However, owing to the patient's thin labial alveolar bone, significant lip protrusion and the biomechanical limitations of orthodontic retraction, this approach poses a risk of periodontal compromise and may not achieve satisfactory aesthetic outcomes. After a comprehensive evaluation of all treatment alternatives and consideration of the patient's primary concern and expectations, a combined orthodontic-surgical approach was deemed the most appropriate to address both functional and aesthetic concerns.

In alignment with the findings of Rivera *et al.*,⁵ it is recommended that orthodontists explicitly encourage patients to articulate their individual goals and reasons for seeking treatment, thereby fostering a more patient-centred approach to care. However, in the South African context, limited support from health funders and medical aid schemes remains a significant deterrent for many patients who require orthognathic surgery for functional and psychosocial reasons. Because many schemes classify these procedures as elective or merely "dental", patients are frequently treated on a self-funded basis, which is a striking example of health inequality that should be urgently addressed. Such restrictive funding policies overlook the profound and well-documented benefits of orthognathic surgery on the functional health, psychosocial well-being and long-term oral rehabilitation of patients.^{19, 20, 21}

To prevent health funders and national health policymakers from ignoring the importance of orthognathic surgery, strong advocacy is needed by professional bodies and patient support groups. Presenting robust evidence of improved quality of life, reduced long-term healthcare costs, and enhanced patient goodwill can help to drive policy changes that ensure equitable access to this life-changing treatment. Orthognathic surgery should therefore be formally classified as an essential surgical procedure, with funding frameworks aligned with evidence-based practice.²²

As Kim *et al.*²² cautioned, excessive retraction in patients with thin cortical bone carries a risk of alveolar compromise. In this case, ASO was favoured over premolar extractions with retraction, since the latter approach risked dehiscence and gingival recession owing to limited bony support.²³ Advances in CBCT have enabled detailed assessment of bone and soft tissue, allowing clinicians not only to diagnose the biological envelope but also to monitor long-term outcomes.²⁴ In this case, a 10-year follow-up CBCT confirmed intact bone and periodontal health within biological limits. ASO was recommended as the treatment of choice to prevent possible alveolar dehiscence from orthodontic retraction in a limited space, which could lead to gingival recession and root exposure.^{9,25,26}

Although anterior segmental osteotomy (ASO) entails greater surgical complexity, it has been associated with fewer periodontal complications and more stable skeletal correction than conventional orthodontic retraction.³ Studies by Baek and Kim² and Harshitha *et al.*²⁶ further support the advantages of ASO, reporting superior improvements in interincisal angle and incisor retraction over shorter treatment durations. In addition, Holte *et al.*¹⁴ confirmed the long-term skeletal and soft-tissue stability achieved with anterior segmental bimaxillary surgery. These findings are reflected in the present case, which demonstrated excellent facial harmony, stable intercuspation, and preserved alveolar bone integrity over a 10-year follow-up period, underscoring the reliability of ASO in improving quality of life by achieving functional and aesthetic treatment objectives.²⁰

Anterior segmental osteotomy (ASO), combined with four premolar extractions and genioplasty in the same surgical procedure, is a complex and technique-sensitive procedure. It requires a highly skilled surgical team and meticulous planning, which has traditionally limited its widespread adoption as a first-line treatment option. However, advancements in digital technology, such as CAD/CAM-assisted splint fabrication and dynamic navigation, have significantly improved multidisciplinary coordination and procedural predictability in bimaxillary surgery.²⁷ These innovations not only reduce operative time and enhance recovery but also improve aesthetic and functional outcomes, leading to increased patient satisfaction as maxillofacial surgery continues to embrace personalised treatment approaches. Consequently, the ASO is likely to become a more accessible and commonly offered treatment option in appropriately selected cases.

CONCLUSION

This case report confirms the long-term efficacy of multidisciplinary collaboration between the orthodontist and maxillofacial oral surgeon in managing adult bimaxillary protrusion, with stable functional and aesthetic outcomes achieved over 10 years. Preservation of alveolar bone health, combined with attention to the patient's goals, underscores

the importance of personalised treatment planning. Sustained advocacy, supported by evidence of improved quality of life and enhanced psychosocial well-being, is vital to ensure that orthognathic surgery is recognised by health funders and policymakers as an equitable, life-changing treatment.

Limitations and Challenges

While this case report presents valuable insights into the long-term success of fixed orthodontic treatment in combination with surgical anterior segmental osteotomy with genioplasty, it remains inherently limited in its contribution to evidence-based practice. Case reports represent the lowest level of clinical evidence owing to their descriptive, non-comparative nature and lack of control over confounding variables. As such, they cannot establish causality or statistical generalisability.

Acknowledgment

The authors gratefully acknowledge the late Professor Tony McCollum for his mentorship during the management of this case, his encouragement to publish it, and his valuable guidance in initiating and structuring the publication process.

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CPD questionnaire on page 424

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 (July 2026)

SADJ JULY 2026, Vol. 81 No.6 P417-P420

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

1. GENTLEWAVE VERSUS CONVENTIONAL SYRINGENEEDLE IRRIGATION IN NONSURGICAL ENDODONTIC TREATMENT

The longterm success of root canal treatment depends on effective disinfection of the complex root canal system. Although mechanical instrumentation removes bulk infected dentine, it cannot reach anatomical irregularities such as fins, isthmuses and lateral canals, which harbour microbial biofilms. Irrigation with antimicrobial solutions therefore plays an indispensable role. Conventional syringeneedle irrigation is the most widely used method, but its efficacy is limited by needle penetration depth and the inability to generate sufficient fluid exchange in the apical third, often leaving substantial areas untouched.

To overcome these limitations, various irrigation activation techniques have been developed, including passive ultrasonic irrigation, sonic activation, and laseractivated irrigation. More recently, the GentleWave® system (Sonendo, Inc.) was introduced as a multisonic, negativepressure irrigation device that combines broadspectrum ultrasonic energy with advanced fluid dynamics to deliver and activate irrigants while simultaneously removing debris via suction. In vitro studies have repeatedly shown that GentleWave achieves superior removal of hardtissue debris, biofilm reduction, and better penetration into lateral canals compared with conventional irrigation. However, clinical data remain scarce and inconsistent. A 2025 systematic review of irrigation adjuncts concluded that although laboratory evidence supports the use of activation devices, wellcontrolled clinical trials have failed to demonstrate a consistent improvement in healing rates over standard needle irrigation. Importantly, no independent study had directly compared GentleWave with conventional irrigation using both periapical radiographs and conebeam computed tomography (CBCT) at a minimum 1year followup. This pragmatic retrospective study aimed to fill that gap by evaluating healing outcomes and success rates in a realworld endodontic practice.

Methodology

This retrospective cohort study was conducted at a university endodontic clinic and adhered to STROBE guidelines. Records of patients treated between June 2021 and June 2023 were screened. Inclusion criteria were: age ≥ 16 years, treatment of a mature permanent tooth requiring initial nonsurgical root canal therapy (NSRCT) or nonsurgical retreatment (NSReTx), good general health (ASA I or II), availability of highquality preoperative and postoperative radiographs, and a minimum followup of 12 months. Teeth with internal/external resorption, vertical root fracture, perforation or severe periodontal bone loss were excluded.

Of 55 charts reviewed, 46 patients (mean age 57.9 years) met the criteria; 20 teeth were treated with GentleWave (GW) and 26 with conventional syringeneedle irrigation (CONV).

All procedures were performed under a dental operating microscope with rubber dam isolation, by operators trained in both techniques. Standardised canal preparation used rotary files, with apical sizes ranging from 30/04 to 45/04. Irrigation volumes were standardised: both groups received 4–6 mL of 6% NaOCl and 2–3 mL of 17% EDTA during instrumentation. Final irrigation in the CONV group was 3 mL EDTA followed by 6 mL NaOCl via 30gauge sidevented needles placed 1–3 mm short of the working length. In the GW group, after final instrumentation, the GW System was used according to the manufacturer's protocol: 5 minutes with 3% NaOCl, a rinse, 2 minutes with 8% EDTA, and a final rinse. All canals were obturated with a hydraulic singlecone technique using bioceramic sealer.

Outcome assessment was performed by two calibrated, blinded evaluators. Periapical radiographs were scored using the Ørstavik PAI index (1–5), and CBCT scans (available for 31 cases) using the CBCTPAI index (0–4). Clinical and radiographic findings were combined to classify outcomes as *healed* (normal, PAI 1–2 or CBCTPAI 0–1), *healing* (normal but reduced score), or *diseased* (symptomatic or no reduction/increase in score). Success was defined using strict (only healed) and *loose* (healed + healing) criteria. Interobserver agreement was assessed with Cohen's kappa. Baseline characteristics and outcomes were compared using Fisher's exact and Wilcoxon ranksum tests; exploratory bivariate analyses identified potential predictors of postoperative PAI score.

Results

The two groups were well balanced at baseline: no significant differences in age, sex, vitality status, prevalence of preoperative periapical radiolucency (PARL, 80% overall), or treatment type (74% initial therapy). Preoperative median PAI (GW 3.75, CONV 4) and CBCTPAI (GW 2.75, CONV 3) scores were similar.

At 12-month followup, both groups showed significant reductions in PAI and CBCTPAI scores ($p < 0.001$). Median postoperative PAI was 1.5 in both groups; median CBCTPAI was 0.5 (GW) vs. 1.5 (CONV), not significantly different. Using PA imaging with strict criteria, healed rates were virtually identical: 70% for GW and 69% for CONV. More CONV cases were classified as "healing" (27% vs. 15%), while more GW cases were "diseased" (15% vs. 4%). Under loose criteria, success was 85% for GW and 96% for CONV. With CBCT, a higher proportion of CONV cases healed (87% vs. 68.7%); all diseased cases on CBCT occurred in the GW group (12.5% vs. 0%). Strictcriteria success on CBCT was 68.7% for GW and 87% for CONV; loosecriteria success was 87.5% vs. 100%. None of these differences

reached statistical significance (Fisher's exact $p > 0.05$ for all). Interobserver agreement was moderate (PA: $\kappa = 0.58$; CBCT: $\kappa = 0.67$).

Exploratory bivariate analyses revealed that in the CONV group, male sex, nonvital pulp, presence of PARL, and absence of preoperative symptoms were associated with higher postoperative PAI scores (i.e., worse healing). In the GW group, only PARL and retreatment (NSReTx) were associated with reduced healing. A significant correlation between PA and CBCT healing classifications was observed only in the GW group ($p = 0.02$).

Conclusion

This first independent clinical comparison of GentleWave versus conventional syringeneedle irrigation, using both PA and CBCT imaging at a 12-month minimum followup, found no statistically significant differences in healing outcomes or success rates between the two irrigation protocols. Both achieved comparable success rates (~70% under strict criteria). The presence of preoperative PARL was the most consistent negative predictor across both groups. Although CBCT imaging suggested a trend favouring conventional irrigation (particularly in the proportion of healed cases), the differences were not significant, and the small sample size limited statistical power (posthoc power analysis indicated that >50 cases per group would be needed to detect a 20% difference). The authors conclude that within the limitations of this retrospective design, the novel GentleWave technology does not confer a clear clinical advantage over standard needle irrigation at 1 year.

Implications for Practice

- **Clinical equipoise remains:** Given the comparable outcomes, clinicians should not assume that the higher

cost of GentleWave equipment and disposables will translate into improved healing rates for typical endodontic cases. Conventional syringeneedle irrigation remains an effective and cost-efficient standard.

- **Case selection matters:** Preoperative PARL was the strongest predictor of poorer outcomes in both groups. Patients with apical periodontitis should be counselled about a potentially lower success rate, irrespective of irrigation method. Retreatment cases also showed reduced healing with GentleWave, possibly because the larger apical preparation sizes required for retreatment may compromise the hydrodynamic performance of the system.
- **Interpretation of imaging:** The significant correlation between PA and CBCT healing only in the GW group suggests that CBCT may detect subtle differences not visible on PA radiographs, but the clinical relevance of these differences remains uncertain. Practitioners should use CBCT judiciously, balancing diagnostic benefit against radiation exposure and cost.
- **Need for robust evidence:** The study's retrospective nature and small sample size underscore the urgent need for adequately powered, multicentre randomised controlled trials with standardised protocols. Until such data emerge, the adoption of GentleWave should be guided by practicespecific factors (case mix, operator experience, financial considerations) rather than a proven superiority in outcomes.

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2. PIEZOSURGERY-ASSISTED PROTOCOL FOR IMPACTED MANDIBULAR THIRD MOLAR REMOVAL WITH 3D SWELLING ANALYSIS

The extraction of impacted mandibular third molars is one of the most common oral surgical procedures. Among impaction types, mesioangulated and horizontally impacted lower third molars (MAHM3Ms) account for up to 80% of all mandibular third molar impactions and are associated with significant postoperative morbidity, including pain, facial swelling, trismus, and occasional nerve injury. The surgical trauma from osteotomy and tooth elevation triggers an acute inflammatory response, which peaks within the first 48–72 hours and can severely affect patients' quality of life.

Conventional extraction techniques rely on rotary handpieces for bone removal and manual elevators for tooth luxation. While effective, these methods can generate heat, cause irregular bone margins, and inadvertently damage adjacent soft tissues. In contrast, piezosurgery uses ultrasonic microvibrations (24–29 kHz) that selectively cut mineralised tissue while sparing soft structures, offering better visibility, haemostasis, and potentially faster bone healing. Numerous systematic reviews and metaanalyses have confirmed that piezosurgery reduces postoperative pain and swelling compared with rotary instruments when used for osteotomy. However, a novel protocol has recently been proposed that extends piezoelectric use beyond osteotomy to include flap elevation and tooth luxation using dedicated "piezolevers". A large parallelgroup study by Fontanella *et al.* (2025) reported favourable results with this

complete piezoelectric approach, but the inclusion of diverse impaction types (vertical, mesioangular, horizontal) limited the ability to draw specific conclusions for MAHM3Ms. Moreover, most previous studies assessed swelling using manual measurements (e.g., tape or calipers), which are operator-dependent and less accurate than three-dimensional (3D) imaging. This randomised splitmouth trial was designed to overcome these limitations by focusing exclusively on MAHM3Ms, applying a consistent piezoelectric protocol for both osteotomy and luxation, and using 3D facial scanning to objectively quantify postoperative swelling.

Methodology

This singleblind, splitmouth randomised controlled trial was conducted at a university hospital in Italy and registered at Clinical Trials (NCT06212232). Patients aged 18–32 years with bilateral, fully impacted MAHM3Ms (according to Winter classification), complete root formation, and good general health (ASA I/II) were eligible. Exclusion criteria included acute infection, chronic systemic diseases, pregnancy, antiresorptive therapy, and recent use of NSAIDs or corticosteroids. Of 98 screened, 47 patients (26 females, 21 males; mean age 25 years) were enrolled. Each patient underwent both surgical protocols, with the side (left or right) randomly allocated to either the piezoelectric test group (TG) or the conventional control group (CG), using computer-generated allocation concealed in opaque

envelopes. A minimum 4week interval separated the two surgeries to avoid carryover effects.

All surgeries were performed by a single experienced oral surgeon. Preoperative CBCT was obtained for all patients to assess anatomy. The test group (TG) protocol used a piezoelectric device (PIEZOSURGERY® white, Mectron) with specific inserts: PR1 for flap elevation, SLOH for pericoronal osteotomy, EX1 for deepening the osteotomy, and EXL1/EXL3 (“piezolevers”) for tooth luxation and extraction. Crown/root sectioning was performed with a highspeed handpiece. The control group (CG) used a Molt #9 dissector for flap elevation, a lowspeed handpiece with round burs for osteotomy, and manual elevators for luxation. All procedures were performed under local anaesthesia, with a single dose of antibiotic prophylaxis (amoxicillin 2 g or clindamycin 600 mg) given 1 hour preoperatively. Postoperative care included paracetamol as needed and 0.2% chlorhexidine rinses.

The primary outcome was facial swelling, quantified by 3D facial scanning (FaceScan MT4000®) at three time points: preoperatively (T0), 2 days (T1), and 7 days (T2) postoperatively. Scans were aligned and analysed using 3D Slicer opensource software; volumetric and linear distance differences were calculated. Secondary outcomes included: surgical time (from incision to extraction completion, excluding suturing); pain intensity on a Visual Analogue Scale (VAS, 0–10) at 4 hours, T1 and T2; maximum mouth opening (interincisal distance); postoperative bleeding (scored 0–3); analgesic consumption; complications (alveolitis, paresthesia); and patientreported outcomes using the PoSSe scale (assessing eating, speech, sensation, appearance, pain, sickness, daily activities) at 7 days, along with patient satisfaction (VAS) and treatment preference at 30 days.

Statistical analyses used paired comparisons (Wilcoxon or ttests as appropriate) and linear regression models to explore associations between swelling and secondary outcomes. Significance was set at $\alpha=0.05$.

Results

All 47 patients completed both surgeries and followup. Baseline tooth characteristics (inclination: 23 horizontal and 24 mesioangulated in CG; 21 and 26 in TG; root morphology comparable) did not differ between groups.

Surgical time was significantly longer in the TG (median 21.43 min, range 14.39–36.04) than in the CG (16.55 min, 9.39–35.06) ($p<0.001$). Despite this, postoperative outcomes favoured the piezoelectric approach. At T1, volumetric facial swelling was significantly lower in the TG (4865.7 mm³) than in the CG (6563.7 mm³) ($p=0.01$). By T2, swelling had decreased in both groups, with no significant difference ($p=0.26$). Pain scores were consistently lower in the TG: at 4 hours (median 3.0 vs. 5.0, $p<0.001$), at T1 (2.0 vs. 3.0, $p<0.001$), and at T2 (1.0 vs. 2.0, $p=0.017$). Maximum mouth opening at T1 was significantly greater in the TG (38.0 mm vs. 36.0 mm, $p=0.016$); at T2, the difference was no longer significant. Postoperative bleeding scores were significantly lower in the TG ($p=0.037$), and analgesic consumption was higher in the CG at both T0 and T2 ($p<0.05$).

Complications were rare: alveolitis occurred in 3 CG and 2 TG sites; all resolved. Transient paresthesia was observed only

in 3 CG cases, all resolving within 4 months. Patientreported outcomes favoured the TG: healing satisfaction VAS was significantly higher ($p=0.039$). The PoSSe scale total score and the “interference with daily activities” domain were significantly lower in the TG (16.8 vs. 21.6, $p=0.001$), with pain, eating, appearance, and daily activities as the most influential factors. Although 29 of 47 patients (62%) expressed a preference for the piezoelectric technique, this did not reach statistical significance ($p>0.05$). Linear regression showed a significant direct correlation between swelling and PoSSe scores in both groups. In the TG, longer surgery time was associated with more pain and bleeding; in the CG, longer time correlated with more swelling and bleeding. Notably, root fracture was correlated with surgery time only in the CG ($p<0.05$), indicating better control with piezosurgery.

Conclusion

This splitmouth RCT demonstrates that a complete piezoelectric protocol (including osteotomy and luxation) for MAHM3M extraction significantly reduces early postoperative inflammatory sequelae—swelling, pain, trismus, and bleeding—compared with conventional rotary and manual techniques. These improvements translate into better patientreported quality of life, particularly regarding interference with daily activities, despite a longer operative time. The piezoelectric approach appears to provide a controlled, atraumatic extraction with less tissue injury, as reflected by the absence of a correlation between surgical time and root fracture in the TG. The authors conclude that this protocol represents a valid minimally invasive alternative, especially for complex MAHM3Ms, and merits wider adoption, although further multicentre studies with larger and more diverse samples are needed to confirm these findings and assess costeffectiveness.

Implications for Practice

- **Enhanced patient experience:** The piezoelectric protocol consistently reduces pain, swelling, and trismus during the critical first postoperative week. This not only improves comfort but also reduces the need for analgesics and allows patients to return to normal activities sooner. For practices managing high volumes of third molar extractions, this can translate into higher patient satisfaction and potentially better compliance with postoperative care.
- **Time versus benefit tradeoff:** The average extra 5 minutes of surgical time (–25% longer) is a notable drawback, particularly in busy clinical settings. However, the improved outcomes may justify this time investment, especially for complex impactions or patients at high risk of postoperative morbidity. As operators gain experience with piezosurgery, the time gap may narrow.
- **Safety and precision:** The absence of a significant correlation between operative time and root fracture in the piezosurgery group suggests that this technique offers greater control, reducing the risk of iatrogenic damage. The lower incidence of temporary paresthesia (0% in TG vs. 12.5% in CG) further supports the safety profile, although the numbers were small.

- **Objective assessment:** The use of 3D facial scanning provided an accurate, reproducible measure of swelling, eliminating the subjectivity of traditional methods. While such technology may not be available in all settings,

clinicians should consider adopting digital tools for research and quality improvement; alternatively, simple photographic protocols can aid in monitoring and patient communication.

Cost and training considerations: Piezosurgery equipment represents a significant capital investment, and the technique requires dedicated training. The initial learning curve may initially prolong surgery times, but the evidence from this study—conducted by a single experienced surgeon—suggests that with proficiency, the benefits outweigh the drawbacks. Practices should weigh the costs against the potential for improved outcomes and patient satisfaction, particularly if they treat a high volume of impacted third molars.

Patient selection and counselling: The study focused exclusively on healthy young adults (18–32 years) with MAHM3Ms. The benefits may be less pronounced in older patients or those with systemic conditions, and generalisation to other impaction types (vertical, distoangular) requires further study. Clinicians should discuss the pros and cons of each technique with patients, acknowledging that the piezoelectric approach may offer a more comfortable recovery at the expense of longer operative time and potentially higher cost.

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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.



The Ethics of Necessary Care: *Primum Nihil Superfluum*

SADJ JULY 2026, Vol. 81 No.6 P421

D Pagollang Motloba

ABSTRACT

Contemporary dentistry is experiencing an ethical transition from an intervention-centred model toward a necessity-centred model. This paradigm shift from avoidance of harm toward deliberate justification for treatment as captured by the formulation *primum nihil superfluum* or “first, do nothing unnecessary.” The principle does not replace *primum non nocere* (“first, do no harm”). Instead, this principle extends non-maleficence by requiring clinicians to consider whether an intervention is clinically indicated, proportionate, evidence-based and aligned with the patient’s interests. This distinction is particularly important in dentistry because many procedures are irreversible, cumulative and capable of initiating a restorative cycle. Ethical implications are evident in all aspects of clinical dentistry, be it diagnostic imaging, restorative, aesthetic dentistry, replacement and oral surgery, among others. The ethically preferable treatment is not simply the procedure that can be performed with the least risk, but the least invasive intervention that is sufficient to achieve the patient’s legitimate oral health goals. Thus, ethical sequence in clinical dentistry should adopt, necessity, proportionality and safety

Keywords

non-maleficence; overtreatment; minimal intervention dentistry; proportionality; informed consent.

INTRODUCTION

Primum non nocere, commonly translated as “first, do no harm,” has long served as a concise expression of the clinician’s obligation to avoid causing injury.¹⁻³ In dentistry, this obligation includes preventing procedural complications, limiting unnecessary tissue damage, reducing radiation exposure and ensuring that treatment is delivered competently.⁴ The principle remains indispensable because dental interventions may produce pain, biological damage, financial burden and long-term treatment consequences even when they are undertaken competently and with therapeutic intent.

However, the avoidance of direct harm does not resolve every ethical problem. For example, procedure may be technically possible in the hands of competent clinician; a patient might concur with clinical recommendation and given informed consent, and the procedure might be associated with a low probability of immediate and long-term complications. However, if the procedure is regarded as unnecessary at that point, this would raise serious ethical issues. For example,

replacing functional restoration, preparing an intact tooth for an elective restoration, or obtaining radiographs without a diagnostic purpose. While these procedures may not always produce obvious short-term injury, they may expose patients to financial, and clinical risks and harm.

The ethical question therefore extends beyond whether treatment can be performed safely, but whether treatment should be performed at all? This ethical tension, represents, the emerging clinical principle, *primum nihil superfluum*, or “first, do nothing unnecessary.” This ethical posture is not a substitute for the established principles of non-maleficence, beneficence, autonomy and justice.⁵ However, it provides a useful normative framework for examining the rising challenge of unnecessary intervention and overtreatment in contemporary dentistry.⁴ The proposed paradigm shift should consequently be understood as an expansion of clinical responsibility. The dentist remains accountable not only for the technical quality of an intervention, but also for ensuring that treatment is necessary, proportionate, evidence based and cost effective. This article develops that argument and considers its moral, legal and practical implications for dental practice.

From Harm Avoidance to Necessity

The principle of *primum non nocere* is primarily concerned with the relationship between an intervention and its potential harm.^{3,6,7} It directs the clinician to identify foreseeable risks, reduce complications and avoid conduct that falls below accepted professional standards. Its central question is: “Can an intervention be performed without causing undue harm?” Treatment may be ethically justified when its expected benefits outweigh its risks and when it is delivered in accordance with professional competence and accepted standards of care. This established model of care is well established in dentistry but is essentially incomplete. A risk-benefit analysis presupposes that an intervention is already a reasonable option. If treatment is unnecessary, even though low risk, it may be classified as being disproportionate because the patient would have been better served by prevention, monitoring, non-operative management or no treatment.

Clinical scenario

A 22-year-old patient undergoes a routine examination. Bitewing radiographs reveal a small proximal enamel lesion on the distal surface of a premolar, confined to enamel. There is no obvious clinical cavitation, and the patient demonstrates good oral hygiene, low caries risk, and regular dental attendance. The dentist recommends and completes Class II composite restoration, competently without any immediate complications.

From a *primum non nocere* perspective, the treatment appears acceptable because it is performed competently,

Authors Information

1. D Pagollang Motloba, BDS (Medunsa), MPH (Epidemiology) (Tulane), M Dent (Comm Dent) ORCID:0000-0003-1379-7576

Corresponding author

Name: D Pagollang Motloba
Email: pagollang.motloba@smu.ac.za

safely and carries a low risk of harm. However, *primum nihil superfluum* raises a question “not whether a procedure is safe, but whether the procedure is necessary, supported by evidence and proportionate to the patient’s condition and goals”? This principle requires the clinician to consider the expected benefit of treatment relative to three alternatives: no treatment, delayed treatment with monitoring, and a less invasive treatment. The two principles therefore operate sequentially rather than competitively. First, the clinician determines whether an intervention is necessary. Second, if intervention is justified, the clinician selects the least harmful and most proportionate method of achieving the intended outcome. Third, the clinician has an option not to intervene at all. This is a significant departure from established clinical strategy, and the compulsion to “always” treat.

The Ethical and Legal Basis of *Primum Nihil Superfluum*

The ethical force of *primum nihil superfluum* arises from the interaction of several established principles of biomedical ethics.^{3,6} Non-maleficence remains central because unnecessary procedures may cause biological, psychological or financial harm.⁷ In dentistry, the removal of sound tooth tissue is especially significant because it is often irreversible. A restoration may repair a defect, but the preparation of a tooth can also initiate a sequence of increasingly extensive restorations over the patient’s lifetime, the so called “tooth death spiral”.⁸ Consequently, preservation is not merely a technical preference; it may be a form of harm prevention.

Beneficence requires clinicians to pursue the patient’s welfare rather than electing treatment with “benefits”. Treatment is beneficial only when it improves or protects oral health, meets reasonable and legitimate standards, ensures patient-defined outcomes and preferences.⁹ Treatment must also produce substantially greater benefits than risks. Choosing not to treat could be the best option in meeting the criteria above. Therefore, clinicians must always consider *primum nihil superfluum* as an option. Respect for autonomy reinforces the importance of discussing treatment and non-treatment as standard approach to care.¹⁰ Respecting autonomy is not equivalent to accepting every patient request. The dentist retains a professional obligation not to provide treatment that is clinically unjustified, ineffective or harmful. Valid consent requires a patient be informed about the benefits and risks of treatment or no treatment, in the short and long-term, including potential costs.

Applying the principle of justice to the principle of *primum nihil superfluum* highlights the tension around indiscriminate use of limited resources and fairness.^{11,12} Providing excessive, inappropriate or inadequately supported care is tantamount to diverting or denying critical care to patients with greater need. Overtreatment or over-servicing is particularly prevalent in clinical dentistry for a plethora of reasons.¹³ Such practices may worsen maldistributions of resources, limit access to care and worsen clinical outcomes for indigent populations. Dentists as stewards of scarce resources should guard against indiscriminate use of limited. Ultimately, health resources must be deployed to produce the greatest benefit for the greatest number of patients and population.

Primum nihil superfluum does not confer absolute preference for minimal intervention. In other words, the principle to “do nothing unnecessary” does not mean “do as little as

possible.” Excessive and unjustified restraint can result in delayed diagnosis, progression of disease, pain, avoidable tooth loss or supervised neglect. The framework for *primum nihil superfluum* supports sufficient intervention or the least extensive treatment that can achieve a clinically acceptable and patient-centred outcome, and not minimal intervention. Failure to adhere to the principle of “*primum non nocere*” can attract claims of negligence against the practitioner.¹⁴ A clinician who fails to adhere to the applicable standard of care may attract liability if treatment results in foreseeable injury. The legal analysis of negligence might arise because of poor documentation, failure to secure informed consent etcetera. Technically sound execution of clinical procedure is not a legal deterrent for negligence.¹⁵ Similarly, choosing not to intervene presupposes diligent interrogation of extensive relevant clinician information; considered choice of appropriate intervention and competent execution. Following this framework, could legally safeguard and prevent possible negligence from a practitioner.

Clinical Dentistry, High-Value Care and Emerging Technologies

Dentistry provides a particularly important setting for adoption of *primum nihil superfluum*. Clinical diagnosis and dental treatment frequently involve irreversible procedures. For example, the removal of enamel and dentine, tooth preparation, extraction and periodontal procedures alter the patient’s biological condition permanently. Some restorative treatment intended to preserve a tooth may increase its structural vulnerability or create requirements for future maintenance. The FDI policy statement on Minimal Intervention Dentistry in line with *primum nihil superfluum* suggests a sequential process to mitigate against unnecessary intervention.¹⁶⁻¹⁸ Applying this model to caries management would involve (i) early detection, (ii) caries-risk and activity assessment, (iii) remineralisation, (iv) maintenance of sound tooth tissue, (v) tailored recalls, (vi) minimally invasive operative care and repair. Less emphasis is placed on replacement of defective restorations. According to this model, sound and remineralisable tissue should not be removed unnecessarily. The policy also recognises that repair may provide outcomes comparable to replacement in appropriate cases, making replacement overtreatment in many situations.

The same principles apply to oral surgery, wherein the removal of an asymptomatic third molar should not be treated as routine in the absence of a clear indication.¹⁹ Similarly, in radiology, imaging should be linked to a diagnostic or treatment-planning question rather than habit or convenience. Antibiotics should not substitute for definitive treatment or be prescribed without a sound clinical indication.²⁰

The adoption of artificial intelligence and modern technologies, including highly sensitive diagnostic systems, may increase diagnostic efficacy and accuracy.²¹ However, the consequent rise in the identification of abnormalities, risk markers or radiographic features, may trigger propensity for treatment by clinicians and patients. Caution and restraint should prevail, detection of lesions should not be equated to disease, and prediction with indication for intervention.²² In both cases the advantages conferred by technologies and artificial intelligence, must attract even greater skepticism and clinical judgement from clinicians and accountability from patients.

Decision Framework for Application of *Primum Nihil Superfluum*

This clinical approach ensures that a practitioner proceeds from diagnosis to intervention through a structured assessment of necessity, proportionality, patient values, and alternatives, ensuring that only the least invasive and sufficiently effective treatment is provided.^{1,4,16,17,23}

1. Establish an Accurate Diagnosis

Confirm the presence, nature, and extent of disease or pathology.

2. Assess Disease Activity and Prognosis

Determine whether the condition is active, progressive, stable, or likely to resolve without intervention.

3. Elicit Patient Values and Goals

Clarify the patient's preferences, expectations, circumstances, and desired outcomes.

4. Compare Intervention with Watchful Waiting or Non-Treatment

Evaluate whether treatment provides meaningful benefits over monitoring, prevention, or no immediate intervention.

5. Assess Benefit-Harm Proportionality

Determine whether the expected benefits justify the biological, psychological, financial, and opportunity costs of intervention.

6. Identify and Manage Conflicts of Interest

Consider whether financial, professional, technological, or institutional factors may influence clinical judgment.

7. Facilitate Informed Shared Decision-Making

Provide balanced information about risks, benefits, alternatives, and uncertainties, enabling informed consent.

8. Choose the Least Invasive Effective Intervention

Select the minimum intervention necessary to achieve the desired clinical outcome while preserving healthy tissue and function.

9. Review Outcomes and Reassess Need for Further Care

Monitor results, evaluate effectiveness, and avoid escalation of treatment unless clinically justified.

Conclusion

The shift from *primum non nocere* toward *primum nihil superfluum* represents an expansion, rather than a rejection of traditional dental ethics. The necessity-centred approach requires dentists to ask whether the patient is likely to benefit more from intervention than from prevention, monitoring or no treatment. It also requires attention to proportionality, natural-

tissue preservation, financial interests, resource stewardship, informed consent and long-term treatment consequences.

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CPD questionnaire



Orthodontic–Surgical Correction of Bimaxillary Protrusion: A Decade-Long Case Report Review

1. **Select the CORRECT answer. Bimaxillary protrusion is primarily characterised by:**
 - A. Retroclined incisors and concave profile
 - B. Proclined incisors and convex soft tissue profile
 - C. Deep bite and posterior crossbite
 - D. Mandibular asymmetry
2. **Which answer is CORRECT. Treatment planning based solely on orthodontic biomechanics may lead to:**
 - A. Improved airway only
 - B. Functional improvement but aesthetic dissatisfaction
 - C. Severe periodontal disease
 - D. Mandibular prognathism
3. **Select the CORRECT option. Orthodontic camouflage treatment commonly involves:**
 - A. Molar distalisation
 - B. Enamel reduction only
 - C. Extraction of first premolars with incisor retraction
 - D. Surgical mandibular setback

Smile attractiveness and dental aesthetics: psychological and clinical implications for dental practice

4. **Choose the CORRECT statement. Which of the following BEST describes the impact of dental aesthetics on social perceptions?**
 - A. Dental aesthetics have no measurable effect on social or psychological outcomes.
 - B. Poor dental aesthetics are always viewed as a sign of high intelligence.
 - C. Improved dental aesthetics can enhance self-esteem, quality of life, and social interactions.
 - D. Dental aesthetics only matter in certain cultures.
5. **Select the CORRECT answer. What is the primary effect globalisation and media have on beauty standards, especially in urban areas?**
 - A. They create extreme diversity of beauty ideals, making them less uniform.
 - B. They homogenize beauty standards, leading to increased demand for cosmetic treatments.
 - C. They eliminate cultural influences on perceptions of beauty.
 - D. They have minimal influence on patient expectations in dentistry.

An assessment of third, fourth and fifth year undergraduate students' perceptions of research at Hage Geingob Campus, June 2022

6. **Which of the following statements is CORRECT. Why is research essential?**
 - A. Allows students to develop effective analytical skills
 - B. For economic emancipation
 - C. Research helps with academic excellence
 - D. Fosters universities to collaborate
7. **Select the CORRECT statement. Perceptions of research are important because**
 - A. They determine whether students will pass research
 - B. They aid in collection of data of research projects
 - C. Perceptions determine commitment and quality of research projects done
 - D. They help in opening up future research opportunities

8. **Choose the CORRECT answer. Which of the following is most accountable for students' lack of confidence in doing research?**
 - A. Too much work
 - B. Feeling of insecurity with data analysis
 - C. Inadequate supervision
 - D. Comprehensive writing required

9. **Which answer is CORRECT. How can a positive attitude towards research be fostered amongst students**
 - A. Make students choose easy topics
 - B. Give them more time with research projects
 - C. Allow students to work unsupervised most of the time
 - D. Thorough engagement and mentorship

Mandibular interradicular bone mapping for safe Mini-implant placement in a South African sample

10. **Select the CORRECT statement. Based on the study findings, which statement best reflects the expected interradicular distance (IR) pattern in the anterior region compared to posterior regions?**
 - A. The anterior region is expected to have significantly greater IR values than posterior regions.
 - B. The anterior region is expected to have similar IR values to posterior regions.
 - C. The anterior region is expected to have significantly lower IR values than posterior regions.
 - D. Regional differences in IR are clinically insignificant.
11. **Select the CORRECT option. A clinician is selecting an appropriate vertical depth for mini-implant insertion in the posterior mandible for male and female patients. Based on the sex-distance interaction, which strategy is most suitable to maximise MI safe insertion considering IR?**
 - A. Insert at shallower depths in females and deeper depths in males.
 - B. Insert at increasing depths for both sexes, with particular advantage for females at 12 mm.
 - C. Avoid deep placement because IR decreases with depth.
 - D. Select the same insertion depth regardless of sex because sex has no influence on IR.
12. **Which answer is CORRECT. What was the predefined safety threshold of IR used to identify clinically safe mini-implant placement sites in the study?**
 - A. 2.5 mm
 - B. 2.7 mm
 - C. 2.0 mm
 - D. 3.1 mm

The Total Occlusal Convergence (TOC) of Dental Preparations Made by Students in Preclinical Training

13. **Select the CORRECT answer. What is the clinically acceptable range for total occlusal convergence (TOC)?**
 - A. 0–5 degrees
 - B. 3–8 degrees
 - C. 6–16 degrees
 - D. 18–25 degrees

14. Choose the CORRET answer. Which direction showed significantly higher convergence values in incisors?
- Mesio-distal
 - Bucco-lingual
 - Occlusal
 - Cervical
15. Choose the CORRECT answer. Was there a statistically significant difference in TOC between male and female students?
- Yes, females showed higher values
 - Yes, males showed higher values
 - No significant difference was found
 - The difference was not analysed
16. Which answer is CORRECT. Which tool was used to measure the convergence angle?
- Goniometric microscope
 - Digital caliper
 - MB-Ruler software
 - Optical comparator

What's new for the clinician

17. Select the CORRECT option. What was the primary finding regarding healing outcomes between the GentleWave (GW) and conventional syringe needle irrigation (CONV) groups at the 12 month follow up?
- The GentleWave group showed significantly higher healing rates than the conventional group across all imaging modalities.
 - The conventional group showed significantly higher healing rates than the GentleWave group on CBCT imaging only.
 - There were no statistically significant differences in healing outcomes or success rates between the two groups.
 - The GentleWave group demonstrated superior healing outcomes only in cases with pre operative periapical radiolucency.
18. Choose the CORRECT option. Which of the following was identified as a predictor of reduced healing in the GentleWave group?
- Male sex
 - Absence of pre operative symptoms
 - Pre operative periapical radiolucency (PARL) and non-surgical retreatment
 - Negative pulp vitality
19. Select the CORRECT statement. What was a key limitation of the Amber *et al* study that the authors acknowledged?
- The study was prospective in design, limiting external validity.
 - The sample size was small, with only 20 teeth in the GentleWave group and 26 in the conventional group, increasing the risk of Type II error.
 - The follow up period was only 6 months, which is insufficient to assess healing.
 - The study only included teeth with vital pulps, limiting generalisability.
20. Which answer is CORRECT. In the Antonelli *et al*, split mouth trial, what was the primary outcome measure in this study, and how was it assessed?
- Postoperative pain, assessed using a Visual Analogue Scale (VAS)
 - Facial swelling, quantified using three dimensional (3D) facial scanning
 - Surgical time, measured from incision to suturing completion
 - Alveolitis incidence, assessed clinically at 7 days post operative

Ethics: The Ethics of Necessary Care: Primum Nihil Superfluum

21. Choose the CORRECT option. A 25-year-old patient presents with an early enamel lesion that is non-cavitated, inactive, and unlikely to progress. Which action best reflects the principle of primum nihil superfluum?
- Restore the lesion immediately to prevent future disease
 - Obtain informed consent and proceed with restoration
 - Monitor the lesion and implement preventive measures before considering operative treatment
 - Refer the patient for specialist assessment
 - Restore the lesion using the least invasive restorative material
22. Which statement is CORRECT. Which of the following scenarios presents the strongest ethical justification for operative intervention under primum nihil superfluum?
- A patient requests replacement of a clinically satisfactory restoration for aesthetic reasons alone
 - A dentist wishes to use a newly acquired technology to assess its performance
 - A progressing carious lesion threatens pulpal health despite preventive measures
 - A patient has dental insurance that covers the procedure in full
 - A restoration is more than ten years old
23. Which of the following is CORRECT. A dentist routinely takes panoramic radiographs on all new patients regardless of clinical findings. According to primum nihil superfluum, the primary ethical concern is that:
- The radiographs violate patient autonomy
 - The radiographs may increase diagnostic accuracy excessively
 - The radiographs may represent an unnecessary intervention lacking clinical indication
 - The radiographs are legally prohibited
 - The radiographs are more expensive than bitewings
24. Choose the CORRECT answer. A patient insists on crowning a healthy anterior tooth to improve appearance despite being informed of the irreversible loss of sound tooth structure. What is the most ethically appropriate response?
- Proceed because patient autonomy is paramount
 - Proceed if the patient can afford the treatment
 - Refuse treatment because autonomy never applies in dentistry
 - Recommend a less invasive alternative and decline unjustified treatment if necessary
 - Refer the patient to another practitioner willing to perform the procedure
25. Select the CORRECT algorithm. A dentist is developing a clinical decision-making algorithm based on primum nihil superfluum. Which sequence would be most appropriate?
- Treatment - Risk assessment - Diagnosis - Consent
 - Diagnosis - Necessity assessment - Alternatives - Shared decision-making - Least invasive effective treatment
 - Patient request - Consent - Treatment - Outcome review
 - Diagnosis - Treatment - Justification of treatment
 - Technology assessment - Treatment - Diagnosis

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THE SOUTH AFRICAN DENTAL JOURNAL

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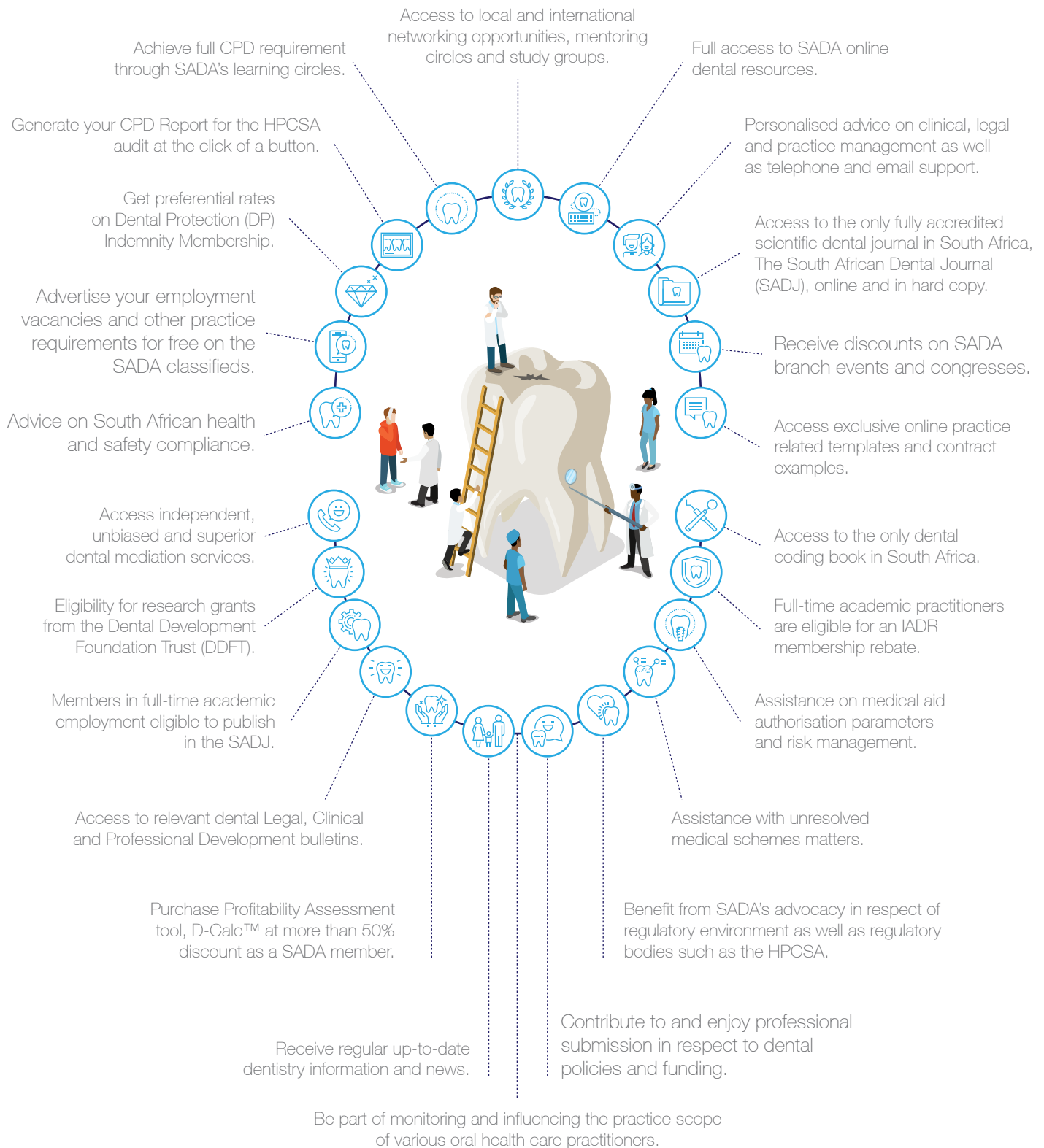
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